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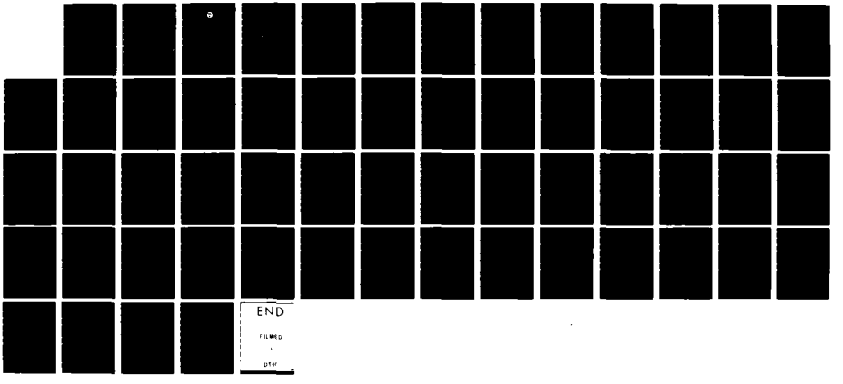

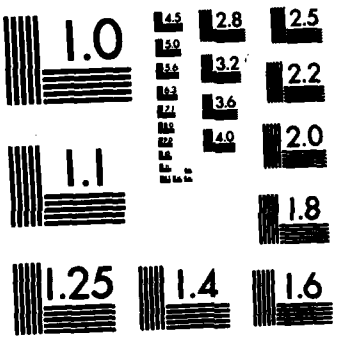

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A GASDYNAMIC ANALYSIS OF A HIGH SPEED PNEUMATIC MISSILE LAUNCHING SYSTEM

S. P. Schneider

30 September 1982

Final Report: 15 April–1 August 1982

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NAVAL OCEAN SYSTEMS CENTER
San Diego, California 92152

NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

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Technical Director

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This paper presents an analysis of a high speed compressed air missile launching system, consisting of a reservoir, valve, and launch tube. Simplifying assumptions are discussed and made, a model is determined, and its numerical solution using FORTRAN is presented.

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SUMMARY

This paper presents an analysis of a high speed compressed air missile launching system, consisting of a reservoir, valve, and launch tube. Simplifying assumptions are discussed and made, a model is determined, and its numerical solution using FORTRAN is presented. The paper concludes with some brief insights and recommendations pertinent to the system design.

LAUNCHER GASDYNAMICS ANALYSIS

Notation

T_f, T_b - flask and barrel (tube) temp, °R

P_f, P_b - flask and barrel pressures, lb_f/ft^2

m_f, m_b - masses of gas in flask and barrel, slugs

$\hat{U}_f$, $\hat{U}_b$ - internal energy per slug of gas in flask and tube, $ft\text{-}lb_f$

x - distance from rear of tube to rear of missile, ft

A_b, A_v - cross-sectional areas of tube, valve, ft^2

V_f - volume of flask, ft^3

V_b - volume of barrel, ft^3

υ - specific volume (per slug), $ft^3/slug$

C_o - zero subscripts are initial values, at t=0

t - time, sec

F_R - release force, lb_f

R - air gas constant, 53.3 $\frac{ft\text{-}lb_f}{lb_m\,°R}$

C_p - specific heat at constant pressure, units of R

C_v - specific heat at constant volume, units of R

m_m - mass of missile, slugs

V_m - velocity of missile, ft/sec.

INTRODUCTION

In connection with the design of the missile launched ASW/Standoff Weapon, the Engineering Branch of the Test Division, Fleet Engineering Department, has been tasked to build a high speed launcher to test the weapon water entry characteristics. Tentative design requirements include water entry angles of 0° to 70° measured from vertical, and entry speeds up to 500 feet/sec. The weapon is expected to be able to withstand accelerations of 300 gs, and to weigh 800 pounds. These parameters, along with the missile geometry, are those determining the design.

The present analysis was begun with the project already in possession of several system components; thus the analysis was designed around the use of those components. The project had taken advantage of an opportunity to acquire two free surplus Polaris launch flasks and a free surplus Polaris launch valve, and had purchased a 30-foot, 2800-psi launch tube. The present work was undertaken with the goal of understanding the fundamental gasdynamics of the system, in order to establish values for the remaining parameters and to confirm the utility of the already acquired components.

The system to be analyzed consists of a launch flask connected by piping to a valve, which is connected to the rear of the launch tube at the end sealed by a breech door, behind the missile (Figure 1). When the valve opens, air rushes from the flask through the valve and piping into the tube, and pressure builds up behind the missile. A release mechanism trips at a certain force and the missile rapidly accelerates out of the tube. The entire system is to be mounted on a rack on a barge in such a manner that the water entry angle can be suitably varied.

An initial literature search revealed that the problem is complex and has not been solved. A somewhat similar system, the Variable Angle Launcher at

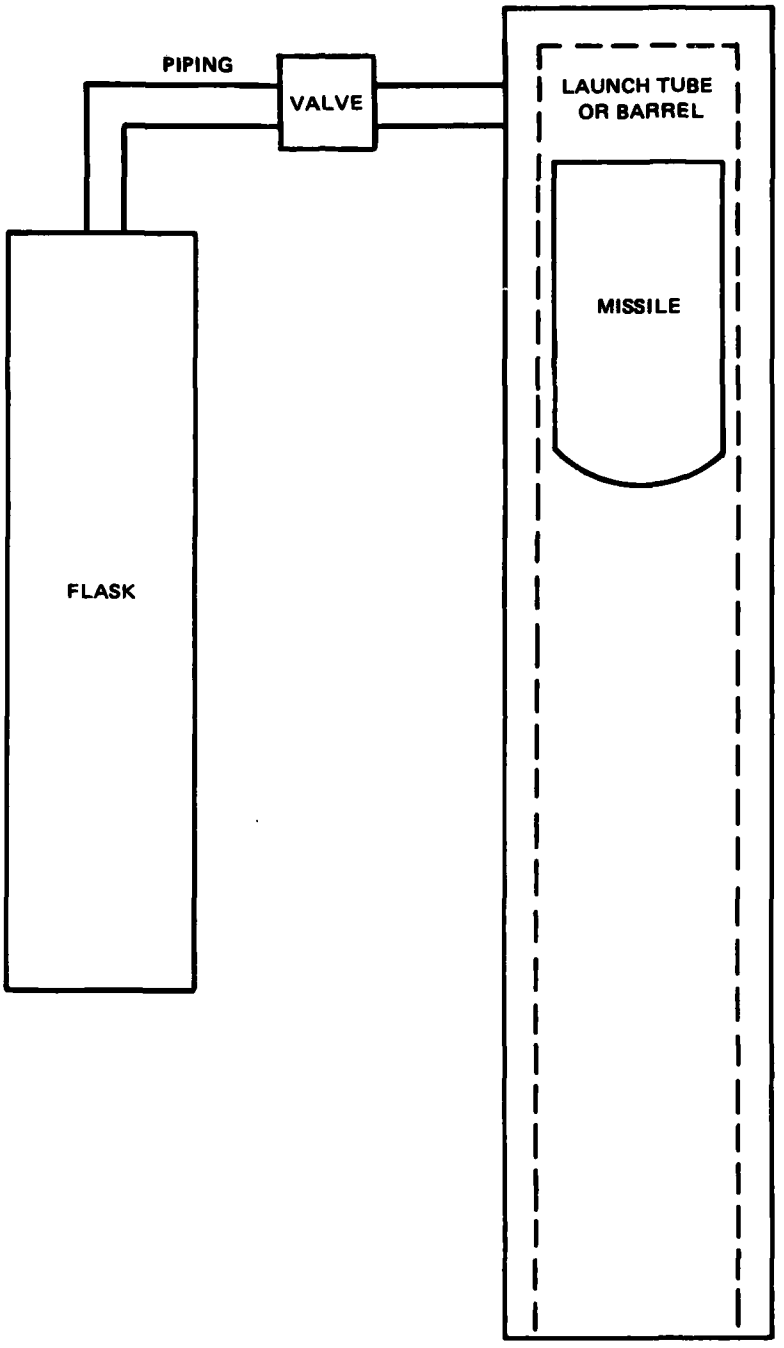

Figure 1. High speed missile launching system (not to scale).

Morris Dam, was built in the 1940's and has yet to be accurately modeled.* It also appeared to be significantly different in the areas of missile friction and air escape. A Fixed Angle Launcher also once existed at Morris Dam; a conversation with one of the designers indicated that fairly crude assumptions were used in the design, and that they worked fairly accurately.** Both these systems seemed to be significantly different from the present one, and tech nical papers which covered in detail the gasdynamics design were not available for either. One accurate theoretical model has been constructed by Dave Nelson for a somewhat similar system, but its methods could not be directly adapted, although it was useful in deciding the level of sophistication necessary to achieve good accuracy. An analysis from fundamentals needed to be completed; it constitutes the bulk of the remainder of this report.

There are three main portions of the system analysis. The first is an analysis of approximations to be made in deciding upon a gasdynamics model; the second, a mathematical analysis of that model; and the third, the numerical solution of the simplified equations for model behavior. The analysis was undertaken with the goal of achieving an accuracy of about 10%.

SYSTEM MODELING APPROXIMATIONS

Air is commonly taken to be a calorically perfect gas, but the high pressures and moderate temperatures involved in this system create significant deviations. Gamma, the ratio of specific heats, varies roughly from 1.4 to 1.6 for the states likely to be encountered in our system.[1] The specific

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* Discussion with Norm Wyman, Morris Dam branch head, May 1982.

** Hudson, Dr. Donald E., Professor of Applied Mechanics, Thomas Laboratory, California Institute of Technology. Telephone conversation and portion of out-of-print report.

1. Hilsenrath, et al., Tables of Thermal Properties of Gases, Washington, D.C., National Bureau of Standards Circular 564, 1955.

heats at constant pressure and volume also vary significantly, although the compressibility factor does not. Values of γ, C_p, and C_v of 1.5, 3.8R, and 2.5R were chosen as mean figures to be used so that the perfect gas approximation would err by less than 10%. The perfect gas approximation was then retained because of its great simplicity.

Conservation of energy and angular momentum were also to be assumed, and it was therefore necessary to investigate which real system effects were important enough to be included in the model. Energy balance considerations were analyzed by relating the magnitude of the effect to the kinetic energy of the exiting missile, which from the design requirements can be calculated as 3.1×10^6 ft-lb_f, or 4000 Btus. It was desirable to conserve only the gas internal energy and missile kinetic energy; thus it was necessary to neglect piping air velocity head, heat transfer, the work involved in restraining recoil, the restraint of earth gravity, missile friction losses, and air escape.

The piping air velocity head could be approximately calculated from the Bernoulli's equation term $\frac{\rho v^2}{2g}$, using for v (the velocity) a value calculated through continuity (knowing the velocity at the choked valve from the ambient temperature) and the approximate pipe dimensions. A maximum of 30 Btus was obtained, which agreed with qualitative expectations for a pipe 6 feet long, and which can easily be neglected.

Heat transfer was calculated using the General Electric Heat Transfer Data Book[2] method for convected flow in a cylinder. It appeared to be on the order of 100 Btu/sec, which was significant but neglectable. It also seemed likely that heat transfer into the cooling flask (the calculated figure) would roughly balance heat transfer out of the tube. The rapid expansion assumption of adiabaticity was therefore made.

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2. GE Heat Transfer Data Book, General Electric Co., Schenectady, New York, 1977.

Recoil was estimated from an angular momentum conservation using data for the YD197 and assuming it was free to rotate in space. Even with this crude method, one finds that the bow vertical velocity of the boat is less than 1 foot/sec, an insignificant energy drain as well as an insignificant momentum drain.

The 1 g involved in earth gravity was very small compared to the 300 g's anticipated for an acceleration peak and was therefore neglected. Gravity induced-missile friction was likewise neglected.

A final factor which was more difficult to analyze was that of air escape past the missile. Besides the obvious energy loss, there is also the question of possible large friction effects from high pressure air forcing the missile against the wall on one side. This problem was not well understood; a pusher plug with close-fitting sizing was incorporated into the design to eliminate it.

Thus it was found allowable to conserve merely gas internal energy and missile kinetic energy, and to ignore the recoil. But it would also be necessary to assume isentropic flow in the valve and flask. How accurate is this assumption?

The first effect of friction and turbulence on the investigated flow is that of the partial choking of pipe flow due to wall friction. Textbook flow friction problems were not easily approximated to our case. However, the indications available were that, for our case of short, large-diameter pipe, the choking problem could be ignored as the pipe flow velocity was not nearly sonic. This conclusion also makes qualitative sense.

A larger question involved in the entropy analysis was the effect of the considerable turbulence in the valve upon the results of an isentropic valve analysis. Because of the difficulty of the entropy concept, an error estimate could not be determined. Dave Nelson's work was useful in indicating that the

isentropic assumption may be made with good accuracy. It is fortunately not necessary to make any entropy assumptions about the highly turbulent tube flow.

As a final step in the model definition, it was necessary to mathematically model the opening of the valve. Data from Polaris experiments, consisting of a set of curves of effective valve opening versus time for various flask pressures, were obtained from Westinghouse, the manufacturer.[3] The curves, obtained from choked flow experiments, were used for both choked and unchoked flow, with uncertain but probably good accuracy. They were quadratically fitted by hand to well within 10 percent.

MATHEMATICAL ANALYSIS

The mathematical model will conserve internal gas and kinetic missile energies, assume an adiabatic system, ignore recoil, and assume frictionless valve and flask flow. Air will be taken to be calorically perfect. Since the valve flow is a complicated subsystem, it will be analyzed first, and then conservation of energy, isentropic flask flow, and Newton's laws will be applied to the system as a whole.

Applying conservation of mass, or continuity, to the valve flow, it is found that

$$\frac{dm}{dt} = \rho VA = \text{constant, at any cross section} \quad . \tag{1}$$

Applying conservation of energy to the flow from flask to valve

$$GC_pT_f + \frac{V_f^2}{2} = GC_pT_V + \frac{V_V^2}{2}$$

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3. Westinghouse Electric Company, Defense Group. Letter Number 82-GSO-108 of 29 April 1982 from G. Stephen Olmstead, and verbal communications wit. Janton of the same group.

where enthalpy is used to include pressure-volume energy considerations in the flow. Rewriting this equation and neglecting flask velocities results in

$$\sqrt{2GC_p(T_f-T_v)} = V_v \quad . \tag{2}$$

Finally, applying the second law and assuming frictionless flask-to-valve flow

$$Tds = du + Pdv = 0 \quad .$$

Using ideal gas laws, the following standard formulas can be derived, which hold for any isentropic change of state:

$$\frac{v_2}{v_1} = \left(\frac{T_2}{T_1}\right)^{\frac{-C_v}{R}} \tag{3a}$$

$$\frac{\rho_2}{\rho_1} = \left(\frac{T_2}{T_1}\right)^{\frac{C_v}{R}} \tag{3b}$$

$$\frac{p_2}{p_1} = \left(\frac{T_2}{T_1}\right)^{\frac{C_v+R}{R}} \tag{3c}$$

$$\frac{\rho_2}{\rho_1} = \left(\frac{P_2}{P_1}\right)^{\frac{C_v}{C_v+R}} \tag{3d}$$

If these three equations are reduced to one, it is found that

$$-\frac{dm_f}{dt} = \frac{P_f}{GRT_f}\left(\frac{P_v}{P_f}\right)^{\frac{C_v}{C_v+R}} A_v\sqrt{2GC_pT_f\left(1-\frac{P_v}{P_f}^{\frac{R}{C_v+R}}\right)}, \qquad (4)$$

which is the standard isentropic nozzle or valve equation. This flow has a maximum which is observed when the throat gas velocity becomes sonic. By differentiating the above expression and setting it to 0, it was found that the flow maximum in the choked state was

$$\frac{dm_f}{dt} = -\frac{P_f}{GRT_f} A_v\sqrt{T_f} \quad (29.6) \qquad (5)$$

with the unit system and perfect gas constants previously selected. The critical pressure ratio below which the flow is choked is also found through the above procedure, and is

$$\frac{P_b}{P_f} = \left(\frac{2C_v+R}{2C_v}\right)^{\frac{C_v+R}{-R}} = .528 \quad .$$

Above this pressure ratio the mass flow rate remains constant and the excess pressure disperses irreversibly through shock waves into the tube. Below this ratio the first equation, (4), applies, and the valve pressure should be approximately the tube pressure; the velocity head is assumed to be primarily dispersed through turbulence into heat, although this is not quite clear.

A total system analysis can now be started by applying the conservation principles previously mentioned. From the first law

$$\hat{U}_f(t)m_f(t) + \hat{U}_b(t)m_b(t) + \frac{1}{2}\, m_m\left(\frac{dx}{dt}\right)^2 = \text{constant}$$

$$= \hat{U}_{fo}m_{fo} + \hat{U}_{bo}m_{bo} \quad .$$

Substituting $U = C_V TG$,

$$C_V T_f(t)m_f(t)G + C_V T_b(t)m_b(t)G + \frac{1}{2}\, m_m\left(\frac{dx}{dt}\right)^2 = GC_V(T_{fo}m_{fo} + T_{bo}m_{bo}) \quad . \qquad (7)$$

Applying Newton's Law to the tube,

$$F = m_m a = m_m \frac{d^2x}{dt^2} = PA \quad .$$

The design was to hold the missile initially with a force-calibrated breaking wire, which is represented as

$$F < F_{release}: \quad F = P_b A_b \qquad (8a)$$

$$F > F_{release}: \quad P_b A_b = m_m \frac{d^2x}{dt^2} \quad . \qquad (8b)$$

Applying conservation of mass

$$m_f + m_b = m_{fo} + m_{bo} \qquad (9a)$$

$$\frac{dm_f}{dt} = \frac{-dm_b}{dt} \quad . \qquad (9b)$$

Finally, assuming a constant flask volume and a reversible flask gas expansion, the following expression can be derived from equations (3),

$$m_{f1}\left(P_{f1}\right)^{\frac{-C_V}{C_V+R}} = m_{fo}\left(P_{fo}\right)^{\frac{-C_V}{C_V+R}} \equiv K_f \quad . \tag{10}$$

Collecting these equations and the ideal gas equation and eliminating mass terms results in the following set of governing equations:

$$\frac{P_b}{P_f} > .528 \qquad (0.26)\left(P_f^{-.29}\right)V_f \frac{dP_f}{dt} = -A_V\sqrt{\frac{V_f}{K_f}(P_f^{.29} - P_b^{.29})}\; P_b^{.71} \tag{11a}$$

$$\frac{P_b}{P_f} < .528 \qquad \frac{dP_f}{dt} = -P_f A_V\sqrt{\frac{1}{V_f K_f}\; P_f^{.29}} \tag{11b}$$

$$2.5P_fV_f + 2.5P_bV_b + \frac{1}{2}m_m\left(\frac{dx}{dt}\right)^2 = K_E \equiv C_V G(T_{fo}m_{fo} + T_{bo}m_{bo}) \tag{12}$$

$$F < F_{release} \qquad F = P_bA_b \tag{13a}$$

$$F > F_{release} \qquad P_bA_b = m_m\frac{d^2x}{dt^2} \tag{13b}$$

where

$$K_f \equiv m_{fo}P_{fo}^{-.71} \text{ and } m_{fo} = \frac{P_{fo}V_{fo}}{GRT_o} \quad .$$

NUMERICAL SOLUTION

These equations completely simulate the flow. They may be combined, but the result is a second order nonlinear differential equation of a form which does not have an analytical solution. It was therefore necessary to numerically solve these equations. This was accomplished using FORTRAN on the Univac 1100/82.

The Euler method was selected as a computer algorithm. It uses the equation

$$y_{j+1} = \frac{dy}{dt}\Big|_j \Delta t + y_j$$

to calculate values for each unknown in a step from the values of the unknowns in the previous step, using the initial conditions as a starting point. Step size must be chosen carefully, but the problem proved to be insensitive to the choice. It was not felt to be worth the effort involved to attempt to make the program user-independent, thus the program is fairly simple. A typical program is listed in Appendix A.

The program consists of a comment heading, parameter initialization, echo print of initialization, a loop which calculates and prints values for each iteration, and a series of DISSPLA plotting statements. The loop calculates the values of the unknowns for each time increment using the initial conditions and the Euler method mentioned above. The loop prints out data for the first 100 iterations and every 100th thereafter, and halts when the missile leaves the tube. Plots are then made of missile acceleration and velocity, and of tube and flask pressure. Appendix B contains the plots corresponding to the parameter choices contained in the program of Appendix A. The program must be modified and recompiled for each parameter change, but the cost is not excessive.

The program was tested for errors, and several were found and corrected. The loop calculation was checked by hand, and plot elements were checked

against analytically derived expectations. Just as this report was being completed, information about a similar launcher at the Naval Ordnance Laboratory in Maryland was received.[4] The program was tested against the maximum muzzle velocity and missile mass case given for their test-pond launcher (Appendix C), which is a fairly well suited test case. The program yields an exit velocity of 393 feet/sec, which closely approximates the observed 380 feet/sec.

DESIGN RECOMMENDATIONS

The program was run with various parameter values and the results were used for design input. It was found that the missile acceleration necessary to reach the required high exit speeds quickly outran the ability of the gas to flow through the valve, even if it was fully open, and so the pressure dropped markedly (for example, see Appendix B). This results in a marked acceleration drop, so that peak acceleration could pass the acceleration limit without the exit velocity reaching the required minimum. This highly peaked acceleration was found to be a function of both slow valve speed and small flask volume. The system requirements and behavior differ markedly from those of the submarine launching system for which the flask and valve were designed. It is not possible to meet the requirements with a choked valve system such as the Polaris system.

Analysis of computer runs with various parameter values leads, along with physical reasoning, to the conclusion that it would be best to design the system to approximate as closely as possible a simple piston-cylinder arrangement. Thus it is recommended that the surplus Polaris equipment be discarded as only marginally adequate, and a pressure vessel of much higher volume be obtained, along with a valving arrangement which permits near instant and very large opening.

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4. Cole, Houston M., "Compressed Air Launchers," U. S. Naval Ordnance Laboratory, White Oak, Maryland. NOLTR 68-191.

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1. Hilsenrath, et al., Tables of Thermal Properties of Gases, Washington, D.C., National Bureau of Standards Circular 564, 1955.

2. GE Heat Transfer Data Book, General Electric Co., Schenectady, New York, 1977.

3. Westinghouse Electric Company, Defense Group. Letter Number 82-GSO-108 of 29 April 1982 from G. Stephen Olmstead, and verbal communications with J. Janton of the same group.

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APPENDIX A

```
@FTN,S FORTRAN.SMALLVAL
FTN 10R1A  07/13/82-08:30[31;]
          1.    *** THIS IS A PROGRAM TO SOLVE THE SYSTEM OF DE'S INVOLVED
          2.    * IN THE GASDYNAMICS ANALYSIS OF THE MINIVAL
          3.    *    WE USE A SIMPLE EULER METHOD, SINCE COMPUTER TIME IS CHEAP,
          4.    * WE ONLY NEED 2 DIGIT ACCURACY, AND OUR EQUATIONS APPEAR TO
          5.    * HAVE A FAIRLY SLOWLY VARYING DERIVATIVE.
          6.    *
          7.    *** ALL WORKING UNITS ARE IN FOOT-POUNDSFORCE-SLUGS SYSTEM
          8.    *
          9.    *** OUR INDEPENDENT VARIABLE IS TIME, T
         10.    *** WE INDEX OUR TIME DIVISIONS WITH THE INTEGER I,
         11.    ***    AND STORE THE VALUES OF FLASK PRESSURE IN ARRAY PFLASK,
         12.    ***    THE VALUES OF BARREL (OR TUBE) PRESSURE IN ARRAY PTUBE,
         13.    ***    THE VALUES OF MISSILE DISPLACEMENT FROM THE REAR WALL IN ARRAY X,
         14.    ***    THE VALUES OF MISSILE VELOCITY IN ARRAY XDOT,
         15.    ***    AND THE VALUES OF MISSILE ACCELERATION IN ARRAY VELDOT.
         16.    *
         17.    *** THE WIDTH OF A TIME DIVISION IS W,
         18.    ***    AND THE TOTAL TIME ELAPSED AT POSITION I IS W*I = T
         19.    *** THE VALVE OPENING AREA IS DESCRIBED BY THE FUNCTION AVALVE
         20.    *** THE CURRENT MISSILE FORCE IS STORED IN THE VARIABLE FORCE
         21.    *** THE MISSILE RELEASE FORCE IS CONTAINED IN THE VARIABLE LETGO
         22.    *** THE INITIAL FLASK PRESSURE IS CONTAINED IN THE VARIABLE PFZERO
         23.    *** THE MISSILE MASS IS CONTAINED IN THE VARIABLE MIMASS
         24.    *** THE TIME DERIVATIVE OF THE FLASK PRESSURE IS CONTAINED IN
         25.    * THE VARIABLE PFDOT
         26.    *
         27.    *** THE EQUATIONS CONTAIN VARIOUS CONSTANTS WHICH WE CALCULATE EXPLICITLY
         28.    ***  WE CALL THE ENERGY EQUATION CONSTANT KENRGY
         29.    ***  WE CALL THE FLASK EXPANSION CONSTANT KFLASK
         30.    ***  WE CALL THE INITIAL FLASK AIR MASS MASSFI
         31.    ***    AND THE INITIAL TUBE AIR MASS MASSTI
         32.    ***  CALL THE INITIAL TUBE PRESSURE PTUBE(0)
         33.    ***    AND THE TUBE CROSS-SECTIONAL AREA ATUBE
         34.    ***    THESE ARE CALCULATED FROM INITIAL CONDITIONS WHICH ARE BASIC:
         35.    ***     THE FLASK VOLUME IS CONTAINED IN VFLASK
         36.    ***     THE INITIAL SYSTEM TEMPERATURE IS CONTAINED IN TEMPO
         37.    ***     THE AIR GAS CONSTANT IS CONTAINED IN R
         38.    ***     THE VALUE OF GRAVITATIONAL ACCEL. IS G = 32.2 FT/SEC2
         39.    *
         40.    *** THE FOLLOWING VARIABLES ARE USED FOR LOGICAL PURPOSES *
         41.    *
         42.    ***    THE VARIABLE GONE IS USED TO TEST FOR WHETHER THE MISSILE
         43.    ***  IS STILL HELD OR NOT
         44.    ***    THE VARIABLE PIECE IS USED TO SPLIT THE UNCHOKED PFDOT
         45.    *** EQUATION INTO TWO PIECES FOR EASE OF CALCULATION AND TO EASILY
         46.    ***  CHECK IF THE SQUARE ROOT IS NEGATIVE (PTUBE > PFLASK ANOMALY)
         47.    ***    THE VARIABLE QUIT IS USED TO TELL THE PLOTTER WHEN
         48.    *** TO QUIT PLOTTING THE POINTS OF THE ARRAYS
         49.    *
         50.          REAL KENRGY,KFLASK
         51.          REAL VFLASK,TEMPO
         52.          REAL R/53.3/,G/32.2/
         53.          REAL MASSTI,MASSFI
         54.          REAL ATUBE
         55.    *
```

```
      *** DECLARE THE VARIABLE TYPES
            REAL PFLASK (0:3000)
            REAL PTUBE (0:3000)
            REAL XDOT (0:3000)
            REAL VELDOT (0:3000)
            REAL X (0:3000)
            REAL TAU (0:3000)
            REAL FORCE
            REAL PFDOT
            REAL PIECE
            LOGICAL GONE
      * THIS IS A VARIABLE TO TEST FOR PREVICUS MISSILE RELEASE
      * IF GONE = .FALSE. THEN MISSILE HAS NOT BEEN RELEASED
      * IF GONE = .TRUE. THEN MISSILE HAS BEEN RELEASED AND CANNOT BE AGAIN HELD
      *
            REAL MIMASS,LETGO
            REAL T,W
            INTEGER I,N,QUIT
      ******* INITIALIZE STEPSIZE AND NUMBER OF STEPS ******
      *
            W = 0.0001
            N = 2980
      *
      ******** INITIALIZE
      ** WHEN CHANGE INITIAL VALUES REMEMBER TO CHANGE PLOT MESSAGES ALSO!!*
      * ! *
            MIMASS = 800/32.2
            PFLASK(0) = 1200*144
            PTUBE(0) = 14.7*144
            XDOT(0) = 0.0
            VELDOT(0) = 0.0
            X(0) = 2.0
            LETGO = 160000
            GONE = .FALSE.
      ***
      ******** INITIALIZE BASIC CONSTANTS ***
            VFLASK = 31.5
            TEMP0 = 520.0
            ATUBE = 3.1416*( 8.5**2 )/144.0
            MASSFI = (PFLASK(0)*VFLASK)/(R*G*TEMP0)
            MASSTI = (PTUBE(0)*X(0)*ATUBE)/(R*G*TEMP0)
            KENRGY = G*2.5*R*TEMP0* (MASSFI + MASSTI)
            KFLASK = MASSFI / (PFLASK(0)**0.71)
      *
      *** WRITE THE VALUES OF THE BASIC PARAMETERS ***
      *
            WRITE (6,11) VFLASK,TEMP0
      11      FORMAT(1X,'FLASK VOLUME IS ',F5.1,5X,'INITIAL TEMP ',F5.1)
            WRITE (6,12) ATUBE
      12      FORMAT(1X,'THE TUBE CROSS-SECTION IS ',F5.3,' SQUARE FEET')
            WRITE (6,10) PFLASK(0)/144.0,MIMASS*32.2,LETGO
      10      FORMAT('0','PFLASK(0) IS ',E14.8,' PSI',5X,'MIMASS IS,LBM',
           CE14.8,5X,'LETGO IS ',E14.8,3X,'POUNDS FORCE')
            WRITE (6,13) MASSFI,MASSTI
      13      FORMAT(1X,'MASSFI IS',E14.8,5X,'MASSTI IS ',E14.8)
            WRITE (6,14) KENRGY,KFLASK
      14      FORMAT(1X,'KENRGY IS ',E14.8,5X,'KFLASK IS ',E14.8)
```

```
      113.    ***
      114.    ******** BEGIN ITERATION
      115.    *** WE CALCULATE AND WRITE VALUES FOR EACH TIME INCREMENT *
      116.    *** AND THEN LOOP BACK TO HERE TO BEGIN A NEW INCREMENT *
      117.    ***
      118.          DO 100 I = 0,N
    1 119.          T = I*W
    1 120.    *
    1 121.    *** CHECK FOR OUT OF BOUND VALUES ***
    1 122.    *
    1 123.          IF ( PFLASK(I)**0.29/(KFLASK*VFLASK) .LT. 0.0 )  STOP 'SQRT OF
    1 124.         C CHOKED FLOW PFDOT EQN IS NEG'
    1 125.    *
    1 126.    ******** STORE THE VALUES OF T FOR PLOT PURPOSES *-----*
    1 127.          TAU(I) = T
    1 128.    *
    1 129.    *******-* SET THE VALVE OPENING VALUE *----*
    1 130.    *
    1 131.          IF (T .LT. 0.65) THEN
    2 132.              AVALVE = 0.44*(T**2) + 0.02*T + 0.02
    2 133.          ELSE
    2 134.              AVALVE = 0.26
    2 135.          END IF
    2 136.    *
    2 137.    *******-* SET THE VALUE OF PFDOT FOR THIS ITERATION *----*
    2 138.    * (FIND IF FLOW IS CHOKED OR NOT) AND THEN WRITE THE INFO ***
    2 139.    *
    2 140.    ********       CHOKED VALVE FLOW  *****
    2 141.    *
    1 142.          IF (PTUBE(I)/PFLASK(I) .LE. 0.528) THEN
    2 143.             PFDOT = -1*PFLASK(I) * AVALVE *
    2 144.         C SQRT( PFLASK(I)**0.29/(KFLASK*VFLASK) )
    2 145.              IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,171)
    2 146.    171         FORMAT('0','THE VALVE IS CHOKED')
    2 147.          ELSE
    2 148.    ********   UNCHOKED VALVE FLOW  ****
    2 149.    *
    2 150.    **********-** DIVIDE UP PFDOT INTO TWO PIECES *
    2 151.    *AND TEST FOR CORRECT ARGUMENT *
    2 152.          PIECE = (PFLASK(I)**0.29 - PTUBE(I)**0.29)/(VFLASK*KFLASK)
    2 153.          IF (PIECE .LT. 0) THEN
    3 154.              WRITE (6,17) PIECE
    3 155.    17       FORMAT(1X,'PIECE HAS THE VALUE ',E14.8,' AND HAS BEEN SET TO 0')
    3 156.              PIECE = 0
    3 157.          END IF
    3 158.    **********-*
    2 159.              PFDOT = -3.8*AVALVE* (PFLASK(I)**0.29) *(PTUBE(I)**0.71) *
    2 160.         C SQRT( PIECE )
    2 161.              IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,170)
    2 162.    170         FORMAT('0','THE VALVE IS UNCHOKED')
    2 163.          END IF
    2 164.    *
    2 165.    ******** IS MISSILE HELD OR RELEASED? ***
    2 166.    *
    1 167.          FORCE = PTUBE(I)*ATUBE
    1 168.          IF (FORCE .LE. LETGO .AND. (GONE .NEQV. .TRUE.)) THEN
    2 169.              VELDOT(I) = 0.0
```

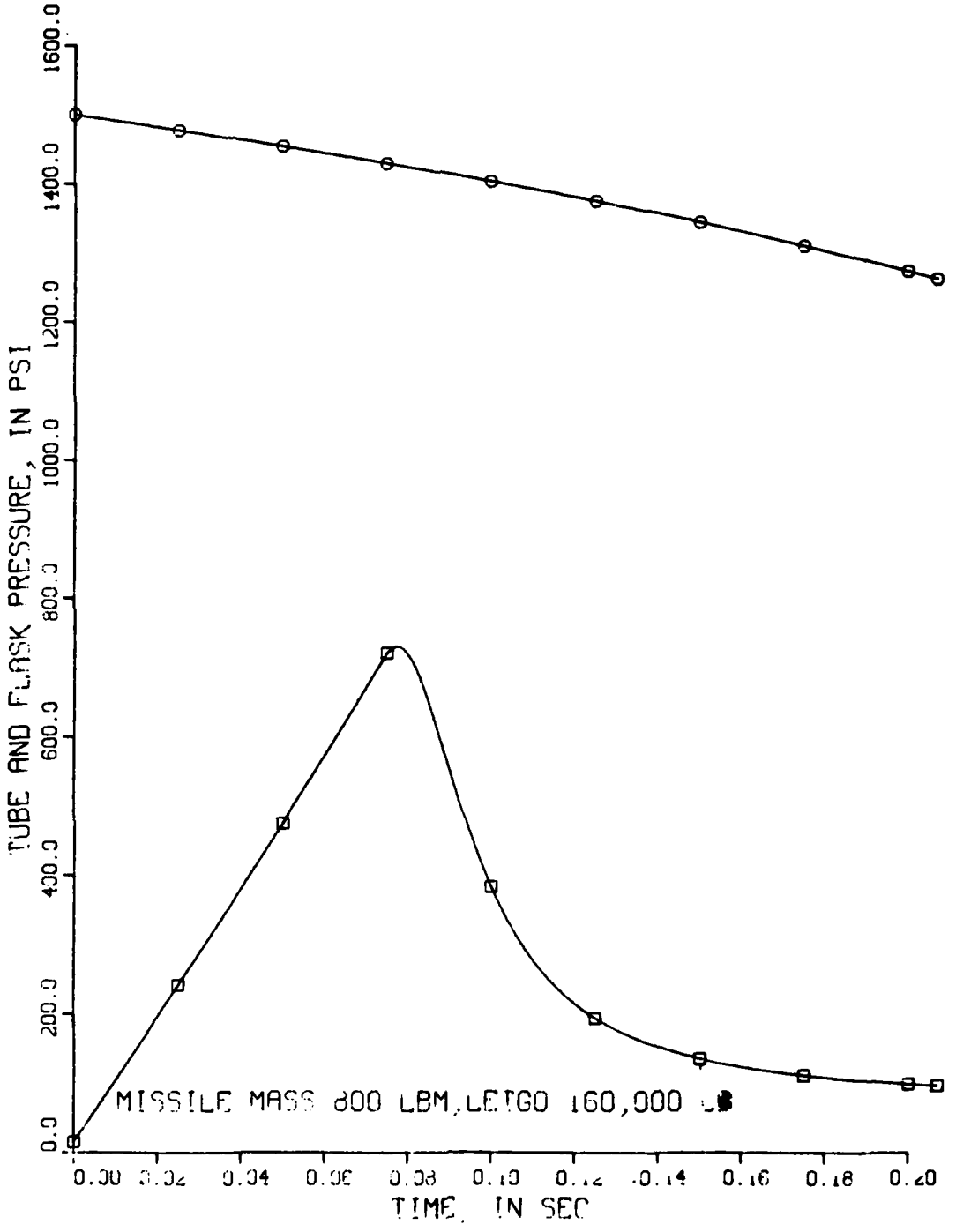
```
2      170.              IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,105)
2      171.    105         FORMAT(1X,'THE MISSILE IS STILL HELD')
2      172.            ELSE
2      173.              VELDOT(I) = FORCE/MIMASS
2      174.              GONE = .TRUE.
2      175.              IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,106)
2      176.    106         FORMAT(1X,'THE MISSILE IS FREE AND ACCELERATING')
2      177.            END IF
2      178.    *
2      179.    ***** CALCULATE THE NEW VALUES FOR THE NEXT TIME INCREMENT **
2      180.    * USING A SIMPLE YNEW = YOLD + DY/DT*DELTA-T TYPE OF FORMULA **
2      181.    ***
1      182.            PFLASK(I+1) = PFLASK(I) + PFDOT*W
1      183.            X(I+1) = X(I) + XDOT(I)*W
1      184.            XDOT(I+1) = XDOT(I) + VELDOT(I)*W
1      185.            PTUBE(I+1) = ( KENRGY - ( 0.5*MIMASS*( XDOT(I+1)**2 ) ) -
1      186.           C (2.5*PFLASK(I+1)*VFLASK) ) / (2.5*X(I+1)*ATUBE)
1      187.    *
1      188.    ******** WRITE THE CALCULATED RESULTS ***
1      189.    * ONLY FOR THE FIRST 100 ITERATIONS AND EVERY 100TH THEREAFTER *
1      190.    *
1      191.    *
1      192.            IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) THEN
1      193.    *
2      194.            WRITE (6,108) 144*AVALVE
2      195.    108       FORMAT(1X,'THE VALVE OPENING SIZE IS (SQRIN) ',E14.8)
2      196.            WRITE (6,109) I,T
2      197.    109       FORMAT(1X,'THIS IS THE CALC FOR POSITION ',I5,5X,'TIME ',E14.8)
2      198.            WRITE (6,110) PFLASK(I)/144, PTUBE(I)/144
2      199.    110       FORMAT(1X,'FLASK PRESSURE IS,PSI,',E14.8,5X,'TUBE PRESSURE IS'
2      200.           C,E14.8)
2      201.            WRITE (6,111) X(I),XDOT(I),VELDOT(I)
2      202.    111       FORMAT(1X,'X IS',E14.8,5X,'XDOT IS ',E14.8,5X,'VELDOT IS ',
2      203.           CE14.8,'UNITS OF FT,SEC')
2      204.            WRITE (6,112) FORCE
2      205.    112       FORMAT(1X,'FORCE = ',E14.8,3X,'POUNDSFORCE')
2      206.    *
2      207.            END IF
2      208.    *
2      209.    ******** CHECK FOR ERRORS AND OUT OF BOUND VALUES ***
2      210.    *
1      211.            IF ( X(I) .GT. 30.0 ) THEN
2      212.              WRITE (6,147) XDOT(I)
2      213.    147         FORMAT('0','****','FINAL VELOCITY IS ',E14.8,' FT/SEC')
2      214.              WRITE (6,148) X(I),PTUBE(I)/144.0,PFLASK(I)/144.0
2      215.    148         FORMAT(1X,'X= ',E14.8,5X,'PTUBE= ',E14.8,5X,'PFLASK= ',
2      216.           CE14.8,' PSI')
2      217.              WRITE (6,146) I,T
2      218.    146         FORMAT(1X,'I IS',I5,5X,'T IS ',E14.8)
2      219.              GO TO 150
2      220.    *         *EXIT THE LOOP*
2      221.            END IF
1      222.            IF ( PTUBE(I) .LT. 0.0 ) STOP 'HALT&DUMP-PTUBE IS NEGATIVE'
1      223.            CALL OVUNFL(L)
1      224.            IF (L .NE. 2) STOP 'OVER OR UNDERFLOW HAS OCCURRED'
1      225.    ***** STORE THE VALUE OF I FOR PLOT PURPOSES ***
1      226.            QUIT = I
```

```
1       227.    *
1       228.    100   CONTINUE
1       229.    ******** PLOT THE DATA ***
1       230.    ** THIS PLOTTING PORTION USES DISSPLA
1       231.    ** IT IS NECESSARY TO LIB N*ADISSPLA
1       232.    ** FOR REFERENCE SEE THE DISSPLA BEGINNERS MANUAL
1       233.    *
1       234.    *
1       235.    *** CONVERT THE PRESSURES TO PSI FOR PLOT PURPOSES ***
        236.    150   DO 200 I = 0,QUIT
1       237.          PTUBE(I) = PTUBE(I)/144.0
1       238.          PFLASK(I) = PFLASK(I)/144.0
1       239.    200   CONTINUE
1       240.    *
1       241.    *** CONVERT THE ACCELERATIONS TO G'S FOR PLOT PURPOSES ***
        242.          DO 300 I = 0,QUIT
1       243.          VELDOT(I) = VELDOT(I)/32.2
1       244.    300   CONTINUE
1       245.    *
        246.          CALL BGNPL(1)
        247.          CALL TITLE('PRESSURE CHARACTERISTICS$',100,'TIME, IN SEC',12,
        248.         C'TUBE AND FLASK PRESSURE, IN PSI$',100,6.0,6.0)
        249.          CALL GRAF(0.0,0.04,0.40,0.0,200.0,1600.0)
        250.          CALL MESSAG('MISSILE MASS 800 LBM,LETGO 160,000 LBS',100,0.3,0.3)
        251.          CALL CURVE(TAU,PTUBE,QUIT,+25)
        252.          CALL CURVE(TAU,PFLASK,QUIT,+25)
        253.          CALL ENDPL(1)
        254.          CALL BGNPL(2)
        255.          CALL TITLE('MISSILE VELOCITY',16,'DISPLACEMENT, FEET$',100,
        256.         C'VELOCITY, FEET/SEC$',100,6.0,8.0)
        257.          CALL MESSAG('(800 LBM, 1200 PSI)$',100,0.8,0.3)
        258.          CALL GRAF(0.0,5.0,35.0,0.0,50.0,700.0)
        259.          CALL CURVE(X,XDOT,QUIT,0)
        260.          CALL ENDPL(2)
        261.          CALL BGNPL(3)
        262.          CALL TITLE('MISSILE ACCELERATION$',100,'TIME, SEC',9,
        263.         C'MISSILE ACCELERATION, G$',100,6.0,8.0)
        264.          CALL GRAF(0.0,0.04,0.40,0.0,50.0,400.0)
        265.          CALL MESSAG('(800 LBM, 1200 PSI)$',100,0.3,0.3)
        266.          CALL CURVE(TAU,VELDOT,QUIT,0)
        267.          CALL ENDPL(3)
        268.          CALL DONEPL
        269.          STOP 'REACHED END OF PROGRAM'
        270.          END

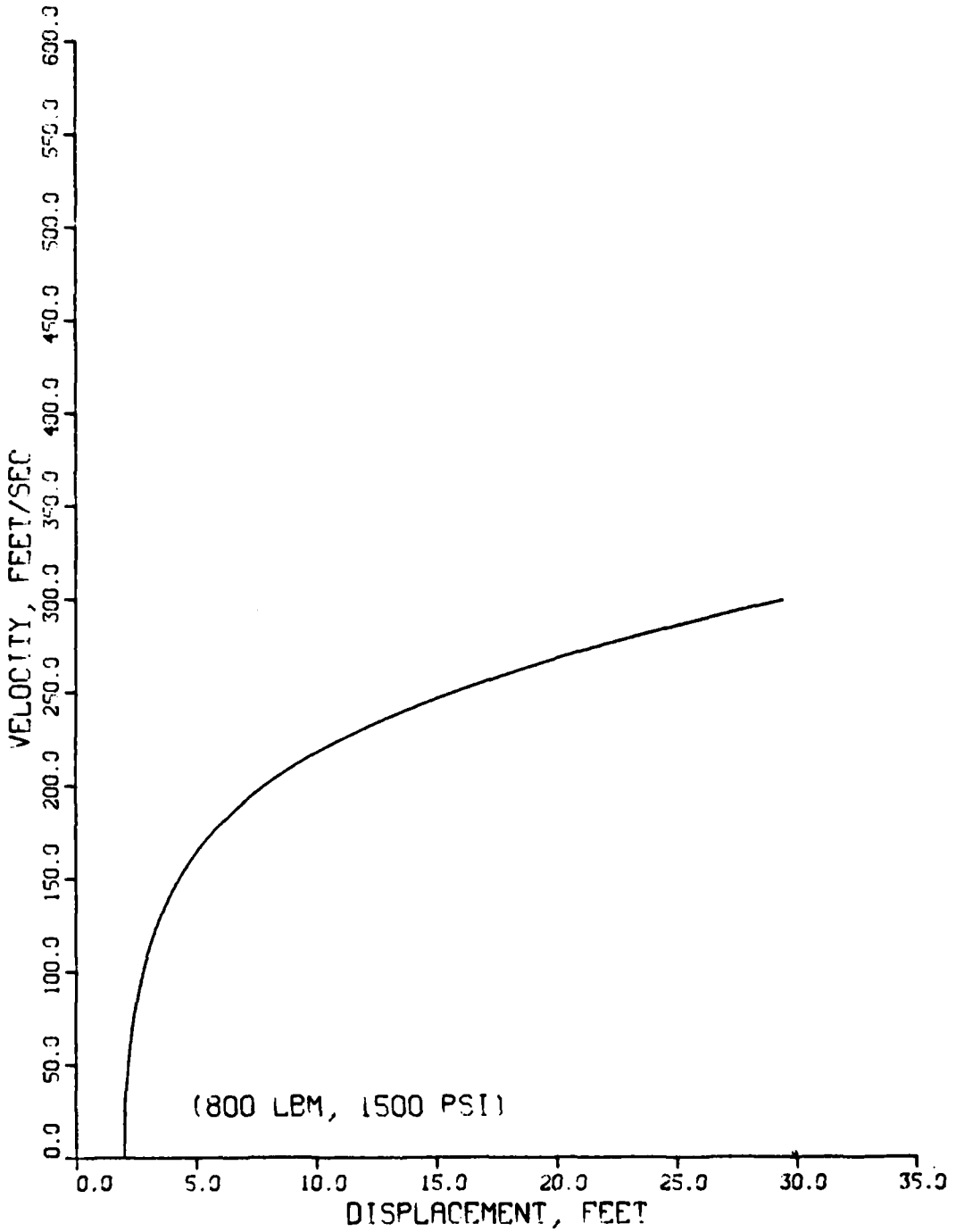
END FTN 414 IBANK 18736 DBANK
```

APPENDIX B

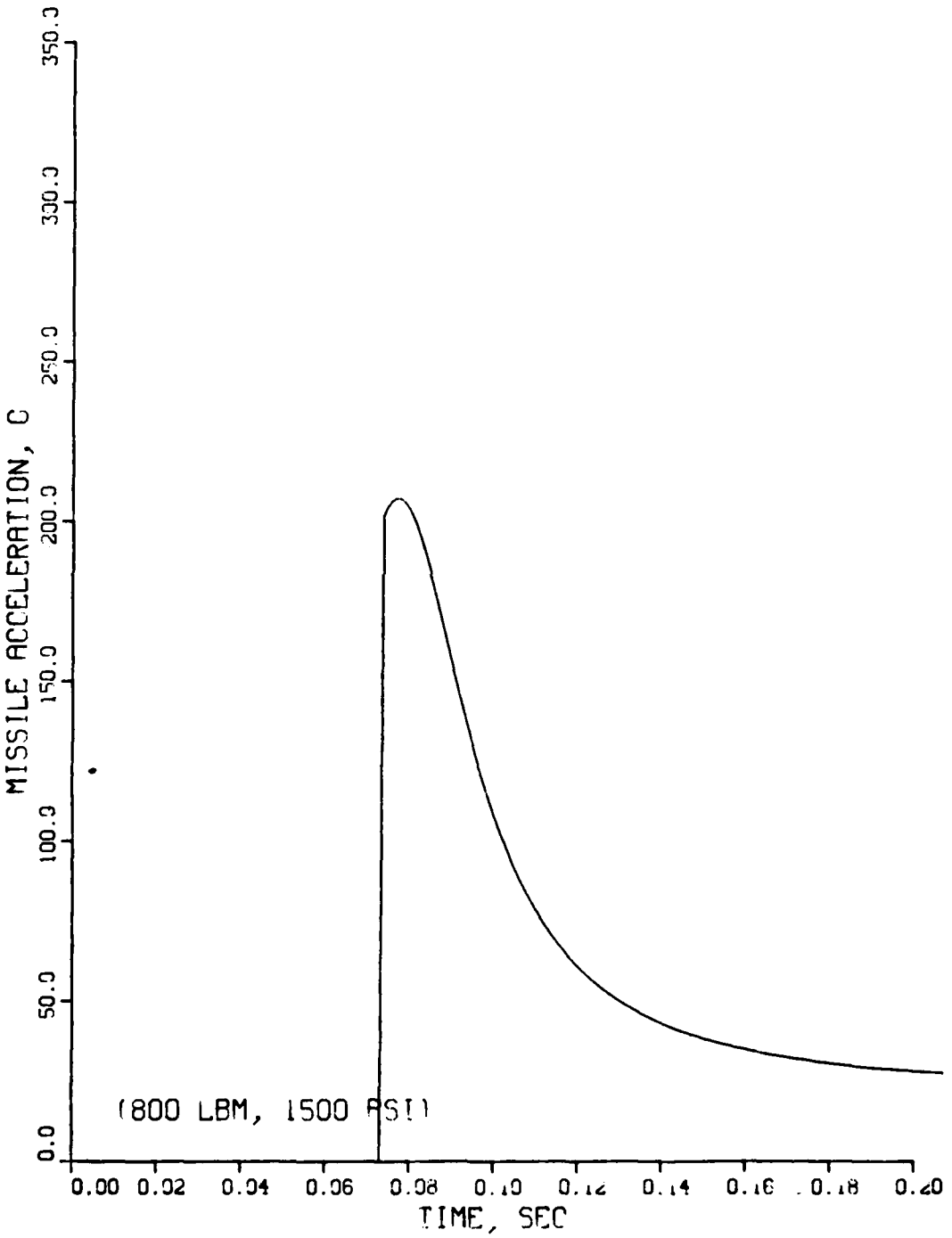
PRESSURE CHARACTERISTICS



MISSILE VELOCITY



MISSILE ACCELERATION



APPENDIX C

```
@FTN,S FORTRAN.SMALLVAL
FTN 10R1A  07/26/82-09:59(34,)
           1.    *** THIS IS A PROGRAM TO SOLVE THE SYSTEM OF DE'S INVOLVED
           2.    * IN THE GASDYNAMICS ANALYSIS OF THE MINIVAL
           3.    *   WE USE A SIMPLE EULER METHOD. SINCE COMPUTER TIME IS CHEAP,
           4.    * WE ONLY NEED 2 DIGIT ACCURACY, AND OUR EQUATIONS APPEAR TO
           5.    * HAVE A FAIRLY SLOWLY VARYING DERIVATIVE.
           6.    *
           7.    *** ALL WORKING UNITS ARE IN FOOT-POUNDSFORCE-SLUGS SYSTEM
           8.    *
           9.    *** OUR INDEPENDENT VARIABLE IS TIME, T
          10.    *** WE INDEX OUR TIME DIVISIONS WITH THE INTEGER I,
          11.    ***   AND STORE THE VALUES OF FLASK PRESSURE IN ARRAY PFLASK,
          12.    ***   THE VALUES OF BARREL (OR TUBE) PRESSURE IN ARRAY PTUBE,
          13.    ***   THE VALUES OF MISSILE DISPLACEMENT FROM THE REAR WALL IN ARRAY X,
          14.    ***   THE VALUES OF MISSILE VELOCITY IN ARRAY XDOT,
          15.    ***   AND THE VALUES OF MISSILE ACCELERATION IN ARRAY VELDOT.
          16.    *
          17.    *** THE WIDTH OF A TIME DIVISION IS W,
          18.    ***   AND THE TOTAL TIME ELAPSED AT POSITION I IS W*I = T
          19.    *** THE VALVE OPENING AREA IS DESCRIBED BY THE FUNCTION AVALVE
          20.    *** THE CURRENT MISSILE FORCE IS STORED IN THE VARIABLE FORCE
          21.    *** THE MISSILE RELEASE FORCE IS CONTAINED IN THE VARIABLE LETGO
          22.    *** THE INITIAL FLASK PRESSURE IS CONTAINED IN THE VARIABLE PFZERO
          23.    *** THE MISSILE MASS IS CONTAINED IN THE VARIABLE MIMASS
          24.    *** THE TIME DERIVATIVE OF THE FLASK PRESSURE IS CONTAINED IN
          25.    * THE VARIABLE PFDOT
          26.    *
          27.    *** THE EQUATIONS CONTAIN VARIOUS CONSTANTS WHICH WE CALCULATE EXPLICITLY *
          28.    ***  WE CALL THE ENERGY EQUATION CONSTANT KENRGY
          29.    ***  WE CALL THE FLASK EXPANSION CONSTANT KFLASK
          30.    ***  WE CALL THE INITIAL FLASK AIR MASS MASSFI
          31.    ***    AND THE INITIAL TUBE AIR MASS MASSTI
          32.    ***  CALL THE INITIAL TUBE PRESSURE PTUBE(0)
          33.    ***    AND THE TUBE CROSS-SECTIONAL AREA ATUBE
          34.    ***   THESE ARE CALCULATED FROM INITIAL CONDITIONS WHICH ARE BASIC:
          35.    ***    THE FLASK VOLUME IS CONTAINED IN VFLASK
          36.    ***    THE INITIAL SYSTEM TEMPERATURE IS CONTAINED IN TEMPO
          37.    ***    THE AIR GAS CONSTANT IS CONTAINED IN R
          38.    ***    THE VALUE OF GRAVITATIONAL ACCEL. IS G = 32.2 FT/SEC2
          39.    *
          40.    *** THE FOLLOWING VARIABLES ARE USED FOR LOGICAL PURPOSES *
          41.    *
          42.    ***    THE VARIABLE GONE IS USED TO TEST FOR WHETHER THE MISSILE
          43.    ***   IS STILL HELD OR NOT
          44.    ***    THE VARIABLE PIECE IS USED TO SPLIT THE UNCHOKED PFDOT
          45.    ***   EQUATION INTO TWO PIECES FOR EASE OF CALCULATION AND TO EASILY
          46.    ***   CHECK IF THE SQUARE ROOT IS NEGATIVE (PTUBE > PFLASK ANOMALY)
          47.    ***    THE VARIABLE QUIT IS USED TO TELL THE PLOTTER WHEN
          48.    ***    TO QUIT PLOTTING THE POINTS OF THE ARRAYS
          49.    *
          50.          REAL KENRGY,KFLASK
          51.          REAL VFLASK,TEMPO
          52.          REAL R/53.3/,G/32.2/
          53.          REAL MASSTI,MASSFI
          54.          REAL ATUBE
          55.    *
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```
*** DECLARE THE VARIABLE TYPES
      REAL PFLASK (0:3000)
      REAL PTUBE (0:3000)
      REAL XDOT (0:3000)
      REAL VELDOT (0:3000)
      REAL X (0:3000)
      REAL TAU (0:3000)
      REAL FORCE
      REAL PFDOT
      REAL PIECE
      LOGICAL GONE
* THIS IS A VARIABLE TO TEST FOR PREVIOUS MISSILE RELEASE
* IF GONE = .FALSE. THEN MISSILE HAS NOT BEEN RELEASED
* IF GONE = .TRUE. THEN MISSILE HAS BEEN RELEASED AND CANNOT BE AGAIN HELD
*
      REAL MIMASS,LETGO
      REAL T,W
      INTEGER I,N,QUIT
******* INITIALIZE STEPSIZE AND NUMBER OF STEPS ******
*
      W = 0.0001
      N = 2980
*
******** INITIALIZE
** WHEN CHANGE INITIAL VALUES REMEMBER TO CHANGE PLOT MESSAGES ALSO!!*
* ! *
      MIMASS = 500/32.2
      PFLASK(0) = 1000*144
      PTUBE(0) = 14.7*144
      XDOT(0) = 0.0
      VELDOT(0) = 0.0
      X(0) = 0.3
      LETGO = 0.0
      GONE = .FALSE.
***
******** INITIALIZE BASIC CONSTANTS ***
      VFLASK = 8.67
      TEMPO = 520.0
      ATUBE = 3.1416*( 7.2**2 )/144.0
      MASSFI = (PFLASK(0)*VFLASK)/(R*G*TEMPO)
      MASSTI = (PTUBE(0)*X(0)*ATUBE)/(R*G*TEMPO)
      KENRGY = G*2.5*R*TEMPO* (MASSFI + MASSTI)
      KFLASK = MASSFI / (PFLASK(0)**0.71)
*
*** WRITE THE VALUES OF THE BASIC PARAMETERS ***
*
      WRITE (6,11) VFLASK,TEMPO
11      FORMAT(1X,'FLASK VOLUME IS ',F5.1,5X,'INITIAL TEMP ',F5.1)
      WRITE (6,12) ATUBE
12      FORMAT(1X,'THE TUBE CROSS-SECTION IS ',F5.3,' SQUARE FEET')
      WRITE (6,10) PFLASK(0)/144.0,MIMASS*32.2,LETGO
10      FORMAT('0','PFLASK(0) IS ',E14.8,' PSI',5X,'MIMASS IS,LBM',
     CE14.8,5X,'LETGO IS ',E14.8,3X,'POUNDS FORCE')
      WRITE (6,13) MASSFI,MASSTI
13      FORMAT(1X,'MASSFI IS',E14.8,5X,'MASSTI IS ',E14.8)
      WRITE (6,14) KENRGY,KFLASK
14      FORMAT(1X,'KENRGY IS ',E14.8,5X,'KFLASK IS ',E14.8)
```

```
      113.    ***
      114.    ******** BEGIN ITERATION
      115.    *** WE CALCULATE AND WRITE VALUES FOR EACH TIME INCREMENT *
      116.    *** AND THEN LOOP BACK TO HERE TO BEGIN A NEW INCREMENT *
      117.    ***
      118.          DO 100 I = 0,N
    1 119.          T = I*W
    1 120.    *
    1 121.    *** CHECK FOR OUT OF BOUND VALUES ***
    1 122.    *
    1 123.          IF ( PFLASK(I)**0.29/(KFLASK*VFLASK) .LT. 0.0 )  STOP 'SQRT OF
    1 124.         C CHOKED FLOW PFDOT EQN IS NEG'
    1 125.    *
    1 126.    ******** STORE THE VALUES OF T FOR PLOT PURPOSES *-----*
    1 127.          TAU(I) = T
    1 128.    *
    1 129.    *******----* SET THE VALVE OPENING VALUE *----*
    1 130.    *
    1 131.          IF (T .LT. 0.0) THEN
    2 132.              AVALVE = 0.44*(T**2) + 0.02*T + 0.02
    2 133.          ELSE
    2 134.              AVALVE = 3.14*25/144
    2 135.          END IF
    2 136.    *
    2 137.    *******----* SET THE VALUE OF PFDOT FOR THIS ITERATION *----*
    2 138.    * (FIND IF FLOW IS CHOKED OR NOT) AND THEN WRITE THE INFO ***
    2 139.    *
    2 140.    ********       CHOKED VALVE FLOW  *****
    2 141.    *
    1 142.          IF (PTUBE(I)/PFLASK(I) .LE. 0.528) THEN
    2 143.             PFDOT = -1*PFLASK(I) * AVALVE *
    2 144.         C SQRT( PFLASK(I)**0.29/(KFLASK*VFLASK) )
    2 145.              IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,171)
    2 146.    171         FORMAT('0','THE VALVE IS CHOKED')
    2 147.          ELSE
    2 148.    *********   UNCHOKED VALVE FLOW  ****
    2 149.    *
    2 150.    ************ DIVIDE UP PFDOT INTO TWO PIECES *
    2 151.    *AND TEST FOR CORRECT ARGUMENT *
    2 152.          PIECE = (PFLASK(I)**0.29 - PTUBE(I)**0.29)/(VFLASK*KFLASK)
    2 153.          IF (PIECE .LT. 0) THEN
    3 154.              WRITE (6,17) PIECE
    3 155.     17     FORMAT(1X,'PIECE HAS THE VALUE ',E14.8,' AND HAS BEEN SET TO 0')
    3 156.              PIECE = 0
    3 157.          END IF
    3 158.    **********
    2 159.              PFDOT = -3.8*AVALVE* (PFLASK(I)**0.29) *(PTUBE(I)**0.71) *
    2 160.         C SQRT( PIECE )
    2 161.              IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,170)
    2 162.    170         FORMAT('0','THE VALVE IS UNCHOKED')
    2 163.          END IF
    2 164.    *
    2 165.    ******** IS MISSILE HELD OR RELEASED? ***
    2 166.    *
    1 167.          FORCE = PTUBE(I)*ATUBE
    1 168.          IF (FORCE .LE. LETGO .AND. (GONE .NEQV. .TRUE.)) THEN
    2 169.              VELDOT(I) = 0.0
```

```
2      170.            IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,105)
2      171.  105           FORMAT(1X,'THE MISSILE IS STILL HELD')
2      172.          ELSE
2      173.              VELDOT(I) = FORCE/MIMASS
2      174.              GONE = .TRUE.
2      175.              IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,106)
2      176.  106           FORMAT(1X,'THE MISSILE IS FREE AND ACCELERATING')
2      177.          END IF
2      178.  *
2      179.  ***** CALCULATE THE NEW VALUES FOR THE NEXT TIME INCREMENT **
2      180.  * USING A SIMPLE YNEW = YOLD + DY/DT*DELTA-T TYPE OF FORMULA **
2      181.  ***
1      182.          PFLASK(I+1) = PFLASK(I) + PFDOT*W
1      183.          X(I+1) = X(I) + XDOT(I)*W
1      184.          XDOT(I+1) = XDOT(I) + VELDOT(I)*W
1      185.          PTUBE(I+1) = ( KENRGY - ( 0.5*MIMASS*( XDOT(I+1)**2 ) ) -
1      186.         C (2.5*PFLASK(I+1)*VFLASK) ) / (2.5*X(I+1)*ATUBE)
1      187.  *
1      188.  ******** WRITE THE CALCULATED RESULTS ***
1      189.  * ONLY FOR THE FIRST 100 ITERATIONS AND EVERY 100TH THEREAFTER *
1      190.  *
1      191.  *
1      192.          IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) THEN
1      193.  *
2      194.          WRITE (6,108) 144*AVALVE
2      195.  108       FORMAT(1X,'THE VALVE OPENING SIZE IS (SQRIN) ',E14.8)
2      196.          WRITE (6,109) I,T
2      197.  109       FORMAT(1X,'THIS IS THE CALC FOR POSITION ',I5,5X,'TIME ',E14.8)
2      198.          WRITE (6,110) PFLASK(I)/144, PTUBE(I)/144
2      199.  110       FORMAT(1X,'FLASK PRESSURE IS,PSI,',E14.8,5X,'TUBE PRESSURE IS'
2      200.         C,E14.8)
2      201.          WRITE (6,111) X(I),XDOT(I),VELDOT(I)
2      202.  111       FORMAT(1X,'X IS',E14.8,5X,'XDOT IS ',E14.8,5X,'VELDOT IS ',
2      203.         CE14.8,'UNITS OF FT,SEC')
2      204.          WRITE (6,112) FORCE
2      205.  112       FORMAT(1X,'FORCE = ',E14.8,3X,'POUNDSFORCE')
2      206.  *
2      207.          END IF
2      208.  *
2      209.  ******** CHECK FOR ERRORS AND OUT OF BOUND VALUES ***
2      210.  *
1      211.          IF ( X(I) .GT. 19.98 ) THEN
2      212.              WRITE (6,147) XDOT(I)
2      213.  147           FORMAT('0','*****','FINAL VELOCITY IS ',E14.8,' FT/SEC')
2      214.              WRITE (6,148) X(I),PTUBE(I)/144.0,PFLASK(I)/144.0
2      215.  148           FORMAT(1X,'X= ',E14.8,5X,'PTUBE= ',E14.8,5X,'PFLASK= ',
2      216.         CE14.8,' PSI')
2      217.              WRITE (6,146) I,T
2      218.  146           FORMAT(1X,'I IS',I5,5X,'T IS ',E14.8)
2      219.              GO TO 150
2      220.  *           *EXIT THE LOOP*
2      221.          END IF
1      222.          IF ( PTUBE(I) .LT. 0.0 ) STOP 'HALT&DUMP-PTUBE IS NEGATIVE'
1      223.          CALL OVUNFL(L)
1      224.          IF (L .NE. 2) STOP 'OVER OR UNDERFLOW HAS OCCURRED'
1      225.  ***** STORE THE VALUE OF I FOR PLOT PURPOSES ***
1      226.          QUIT = I
```

```
1      227.      *
1      228.      100   CONTINUE
1      229.      ******** PLOT THE DATA ***
1      230.      ** THIS PLOTTING PORTION USES DISSPLA
1      231.      ** IT IS NECESSARY TO LIB N=ADISSPLA
1      232.      ** FOR REFERENCE SEE THE DISSPLA BEGINNERS MANUAL
1      233.      *
1      234.      *
1      235.      *** CONVERT THE PRESSURES TO PSI FOR PLOT PURPOSES ***
       236.      150   DO 200 I = 0,QUIT
1      237.            PTUBE(I) = PTUBE(I)/144.0
1      238.            PFLASK(I) = PFLASK(I)/144.0
1      239.      200   CONTINUE
1      240.      *
1      241.      *** CONVERT THE ACCELERATIONS TO G'S FOR PLOT PURPOSES ***
       242.            DO 300 I = 0,QUIT
1      243.            VELDOT(I) = VELDOT(I)/32.2
1      244.      300   CONTINUE
1      245.      *
       246.            CALL BGNPL(1)
       247.            CALL TITLE('PRESSURE CHARACTERISTICS$',100,'TIME, (N SEC',12,
       248.           C'TUBE AND FLASK PRESSURE, IN PSI$',100,6.0,8.0)
       249.            CALL GRAF(0.0,0.04,0.40,0.0,200.0,1600.0)
       250.            CALL MESSAG('MISSILE MASS 500 LBM,NOL TEST$',100,0.3,0.3)
       251.            CALL CURVE(TAU,PTUBE,QUIT,+25)
       252.            CALL CURVE(TAU,PFLASK,QUIT,+25)
       253.            CALL ENDPL(1)
       254.            CALL BGNPL(2)
       255.            CALL TITLE('MISSILE VELOCITY',16,'DISPLACEMENT, FEET$',100,
       256.           C'VELOCITY, FEET/SEC$',100,6.0,8.0)
       257.            CALL MESSAG('(500 LBM, 1000 PSI)$',100,0.8,0.3)
       258.            CALL GRAF(0.0,5.0,35.0,0.0,50.0,700.0)
       259.            CALL CURVE(X,XDOT,QUIT,0)
       260.            CALL ENDPL(2)
       261.            CALL BGNPL(3)
       262.            CALL TITLE('MISSILE ACCELERATION$',100,'TIME, SEC',9,
       263.           C'MISSILE ACCELERATION, G$',100,6.0,8.0)
       264.            CALL GRAF(0.0,0.04,0.40,0.0,50.0,400.0)
       265.            CALL MESSAG('(500 LBM, 1000 PSI)$',100,0.3,0.3)
       266.            CALL CURVE(TAU,VELDOT,QUIT,0)
       267.            CALL ENDPL(3)
       268.            CALL DONEPL
       269.            STOP 'REACHED END OF PROGRAM'
       270.            END

END FTN 412 ISANK 18731 DBANK
```

```
@map maprules.smallval,fortran.smallval
MAP 30R1 S74T11 07/26/82 09:59:49 (3)
START=056133, PROG SIZE(I/D)=23543/38702
SYS$*RICDS. LEVEL 74R1A
END MAP.  ERRORS: 0  TIME: 36.434  STORAGE: 23729/10/040777/0111777

@xqt fortran.smallval
FLASK VOLUME IS   8.7      INITIAL TEMP 520.0
THE TUBE CROSS-SECTION IS 1.131 SQUARE FEET

PFLASK(0) IS  .10000000+004 PSI      MIMASS IS,LBM .50000000+003      LETGC IS  .00000000
MASSFI IS .13982273+001      MASSTI IS  .80476308-003
KENRGY IS  .31229954+007      KFLASK IS  .30433912-003

THE VALVE IS CHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION      0      TIME  .00000000
FLASK PRESSURE IS,PSI, .10000000+004      TUBE PRESSURE IS .14700000+002
X IS .30000000+000      XDOT IS  .00000000      VELDOT IS  .15417682+003UNITS OF FT,SEC
FORCE =  .23940600+004   POUNDSFORCE

THE VALVE IS CHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION      1      TIME  .10000000-003
FLASK PRESSURE IS,PSI, .99406007+003      TUBE PRESSURE IS .16648318+003
X IS .30000000+000      XDOT IS  .15417682-001      VELDOT IS  .17461121+004UNITS OF FT,SEC
FORCE =  .27113542+005   POUNDSFORCE

THE VALVE IS CHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION      2      TIME  .20000000-003
FLASK PRESSURE IS,PSI, .98816053+003      TUBE PRESSURE IS .31723118+003
X IS .30001554+000      XDOT IS  .19002889+000      VELDOT IS  .33271902+004UNITS OF FT,SEC
FORCE =  .51964443+005   POUNDSFORCE

THE VALVE IS CHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION      3      TIME  .30000000-003
FLASK PRESSURE IS,PSI, .98230106+003      TUBE PRESSURE IS .40691354+003
X IS .30002054+000      XDOT IS  .52274790+000      VELDOT IS  .48970914+004UNITS OF FT,SEC
FORCE =  .76041792+005   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION      4      TIME  .40000000-003
FLASK PRESSURE IS,PSI, .97648136+003      TUBE PRESSURE IS .61546013+003
X IS .30007202+000      XDOT IS  .10124570+001      VELDOT IS  .64550806+004UNITS OF FT,SEC
FORCE =  .10022417+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
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NOTE THAT THE MASS OF THE FLASK GAS IS INSIGNIFICANT (45LBM TOTAL) COMPARED TO THE MISSILE MASS, SO THAT ITS ACCELERATION MAY BE IGNORED.

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THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     5      TIME  .49999999-003
FLASK PRESSURE IS,PSI, .97087923+003      TUBE PRESSURE IS .75821222+003
X IS .30017406+000      XDOT IS  .16579651+001      VELDOT IS  .79522959+004UNITS OF FT,SEC
FORCE =  .12348286+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     6      TIME  .60000000-003
FLASK PRESSURE IS,PSI, .96806361+003      TUBE PRESSURE IS .88050108+003
X IS .30033995+000      XDOT IS  .24531946+001      VELDOT IS  .92348882+004UNITS OF FT,SEC
FORCE =  .14339608+006   POUNDSFORCE
PIECE HAS THE VALUE -.38213907+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     7      TIME  .70000000-003
FLASK PRESSURE IS,PSI, .96275447+003      TUBE PRESSURE IS .90383526+003
X IS .30058517+000      XDOT IS  .33766834+001      VELDOT IS  .10108915+005UNITS OF FT,SEC
FORCE =  .15697073+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     8      TIME  .80000000-003
FLASK PRESSURE IS,PSI, .96275447+003      TUBE PRESSURE IS .96225637+003
X IS .30092284+000      XDOT IS  .43875750+001      VELDOT IS  .10092355+005UNITS OF FT,SEC
FORCE =  .15671360+006   POUNDSFORCE
PIECE HAS THE VALUE -.15795720+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     9      TIME  .90000000-003
FLASK PRESSURE IS,PSI, .96248984+003      TUBE PRESSURE IS .96096202+003
X IS .30136159+000      XDOT IS  .53968105+001      VELDOT IS  .10141709+005UNITS OF FT,SEC
FORCE =  .15747096+006   POUNDSFORCE
PIECE HAS THE VALUE -.70255507+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    10      TIME  .99999999-003
FLASK PRESSURE IS,PSI, .96248984+003      TUBE PRESSURE IS .96447714+003
X IS .30190127+000      XDOT IS  .64109814+001      VELDOT IS  .10115648+005UNITS OF FT,SEC
FORCE =  .15707527+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    11      TIME  .11000000-002
FLASK PRESSURE IS,PSI, .96248984+003      TUBE PRESSURE IS .96155155+003
X IS .30254237+000      XDOT IS  .74225461+001      VELDOT IS  .10084963+005UNITS OF FT,SEC
FORCE =  .15659881+006   POUNDSFORCE
PIECE HAS THE VALUE -.18518637+002 AND HAS BEEN SET TO 0
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NOTE THAT THIS GLITCH IS DUE TO STEPSIZE CHOICE AND DOES NOT APPEAR TO MATERIALLY AFFECT THE SOLUTION, AS INDICATED BY RUNS WITH SMALLER STEPSIZES.

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THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     12      TIME  .12000000-002
FLASK PRESSURE IS,PSI, .96212677+003      TUBE PRESSURE IS .9673696+003
X IS .3032[illegible]+000      XDOT IS  .84310424+001      VELDOT IS  .10145988+005UNITS OF FT,SEC
FORCE =  .1575[illegible]+006   POUNDSFORCE
PIECE HAS THE VALUE -.50375094+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     13      TIME  .13000000-002
FLASK PRESSURE IS,PSI, .96212677+003      TUBE PRESSURE IS .963551C3+003
X IS .3041277[illegible]+000      XDOT IS  .94456412+001      VELDOT IS  .10105934+005UNITS OF FT,SEC
FORCE =  .1569245+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     14      TIME  .14000000-002
FLASK PRESSURE IS,PSI, .96212677+003      TUBE PRESSURE IS .95931050+003
X IS .3050722[illegible]+000      XDOT IS  .10456235+002      VELDOT IS  .10061459+005UNITS OF FT,SEC
FORCE =  .1562338[illegible]+006   POUNDSFORCE
PIECE HAS THE VALUE -.31383528+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     15      TIME  .15000000-002
FLASK PRESSURE IS,PSI, .96149856+003      TUBE PRESSURE IS .97039202+003
X IS .3061179[illegible]+000      XDOT IS  .11462380+002      VELDOT IS  .10177684+005UNITS OF FT,SEC
FORCE =  .1570[illegible]+006   POUNDSFORCE
PIECE HAS THE VALUE -.13297702+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     16      TIME  .16000000-002
FLASK PRESSURE IS,PSI, .96149856+003      TUBE PRESSURE IS .96525977+003
X IS .3072641[illegible]+000      XDOT IS  .12480149+002      VELDOT IS  .10123856+005UNITS OF FT,SEC
FORCE =  .1572027[illegible]+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     17      TIME  .17000000-002
FLASK PRESSURE IS,PSI, .96149856+003      TUBE PRESSURE IS .95972972+003
X IS .3085121[illegible]+000      XDOT IS  .13492534+002      VELDOT IS  .10065856+005UNITS OF FT,SEC
FORCE =  .157[illegible]+006   POUNDSFORCE
PIECE HAS THE VALUE -.18152419+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     18      TIME  .18000000-002
FLASK PRESSURE IS,PSI, .96100062+003      TUBE PRESSURE IS .9661356?+003
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X IS .3098611+000      XDOT IS  .14499120+002      VELDOT IS .10133042+005UNITS OF FT,SEC
FORCE =  .15734538+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     19      TIME  .19000000-002
FLASK PRESSURE IS,PSI, .9610006Z+003      TUBE PRESSURE IS .95977307+003
X IS .3113113Z+000      XDOT IS  .15512424+002      VELDOT IS  .10066310+005UNITS OF FT,SEC
FORCE =  .15630916+006   POUNDSFORCE
PIECE HAS THE VALUE -.92960486+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     20      TIME  .20000000-002
FLASK PRESSURE IS,PSI, .9605858Z+003      TUBE PRESSURE IS .9602120+003
X IS .3128625Q+000      XDOT IS  .16519055+002      VELDOT IS  .10102382+005UNITS OF FT,SEC
FORCE =  .15668028+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     21      TIME  .21000000-002
FLASK PRESSURE IS,PSI, .9605858Z+003      TUBE PRESSURE IS .95606800+003
X IS .3145144Z+000      XDOT IS  .17529293+002      VELDOT IS  .10027451+005UNITS OF FT,SEC
FORCE =  .15570576+006   POUNDSFORCE
PIECE HAS THE VALUE -.28433633+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     22      TIME  .22000000-002
FLASK PRESSURE IS,PSI, .9597917Z+003      TUBE PRESSURE IS .95783661+003
X IS .3162673Q+000      XDOT IS  .18532038+002      VELDOT IS  .10150882+005UNITS OF FT,SEC
FORCE =  .15702240+006   POUNDSFORCE
PIECE HAS THE VALUE -.31769624+000 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     23      TIME  .23000000-002
FLASK PRESSURE IS,PSI, .9597917Z+003      TUBE PRESSURE IS .95988126+003
X IS .3181206Q+000      XDOT IS  .19547126+002      VELDOT IS  .10067446+005UNITS OF FT,SEC
FORCE =  .15833980+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     24      TIME  .24000000-002
FLASK PRESSURE IS,PSI, .9597917Z+003      TUBE PRESSURE IS .96161417+003
X IS .3200753Z+000      XDOT IS  .20553870+002      VELDOT IS  .99807379+004UNITS OF FT,SEC
FORCE =  .15498040+006   POUNDSFORCE
PIECE HAS THE VALUE -.34244872+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
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THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     25      TIME  .25000000-002
FLASK PRESSURE IS,PSI, .95872613+003      TUBE PRESSURE IS .96841346+003
X IS .3221300?+000      XDOT IS  .21551944+002      VELDOT IS  .10156932+005UNITS OF FT,SEC
FORCE =  .15771604+006   POUNDSFORCE
PIECE HAS THE VALUE -.21859236+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     26      TIME  .26000000-002
FLASK PRESSURE IS,PSI, .95872613+003      TUBE PRESSURE IS .95934243+003
X IS .3242858?+000      XDOT IS  .22567637+002      VELDOT IS  .10061794+005UNITS OF FT,SEC
FORCE =  .15923903+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     27      TIME  .27000000-002
FLASK PRESSURE IS,PSI, .95872613+003      TUBE PRESSURE IS .95000107+003
X IS .3265421?+000      XDOT IS  .23573817+002      VELDOT IS  .99638193+004UNITS OF FT,SEC
FORCE =  .15771769+006   POUNDSFORCE
PIECE HAS THE VALUE -.29777969+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     28      TIME  .28000000-002
FLASK PRESSURE IS,PSI, .95762656+003      TUBE PRESSURE IS .96603952+003
X IS .3288000?+000      XDOT IS  .24570198+002      VELDOT IS  .10132034+005UNITS OF FT,SEC
FORCE =  .15732972+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     29      TIME  .29000000-002
FLASK PRESSURE IS,PSI, .95762656+003      TUBE PRESSURE IS .95595198+003
X IS .3310579?+000      XDOT IS  .25583402+002      VELDOT IS  .10026234+005UNITS OF FT,SEC
FORCE =  .15688086+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     30      TIME  .30000000-002
FLASK PRESSURE IS,PSI, .95714330+003      TUBE PRESSURE IS .95673532+003
X IS .3331952?+000      XDOT IS  .26586025+002      VELDOT IS  .10034450+005UNITS OF FT,SEC
FORCE =  .15581444+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     31      TIME  .31000000-002
FLASK PRESSURE IS,PSI, .95699469+003      TUBE PRESSURE IS .95153282+003
X IS .3353739?+000      XDOT IS  .27589470+002      VELDOT IS  .99756845+004UNITS OF FT,SEC
FORCE =  .15496715+006   POUNDSFORCE
PIECE HAS THE VALUE -.14581137+002 AND HAS BEEN SET TO 0
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THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    32      TIME  .32000000-002
FLASK PRESSURE IS,PSI, .95604135+003      TUBE PRESSURE IS .96014949+003
X IS .30933293+000      XDOT IS  .28587458+002      VELDOT IS  .10070258+005UNITS OF FT,SEC
FORCE =  .15637047+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    33      TIME  .33000000-002
FLASK PRESSURE IS,PSI, .95604135+003      TUBE PRESSURE IS .94886310+003
X IS .34219157+000      XDOT IS  .29594484+002      VELDOT IS  .99518840+004UNITS OF FT,SEC
FORCE =  .15153236+006   POUNDSFORCE
PIECE HAS THE VALUE -.15995048+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    34      TIME  .34000000-002
FLASK PRESSURE IS,PSI, .95504494+003      TUBE PRESSURE IS .95954877+003
X IS .33515112+000      XDOT IS  .30589672+002      VELDOT IS  .10063958+005UNITS OF FT,SEC
FORCE =  .15627263+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    35      TIME  .35000000-002
FLASK PRESSURE IS,PSI, .95504494+003      TUBE PRESSURE IS .94769219+003
X IS .34821009+000      XDOT IS  .31596068+002      VELDOT IS  .99396033+004UNITS OF FT,SEC
FORCE =  .15484167+006   POUNDSFORCE
PIECE HAS THE VALUE -.12994644+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    36      TIME  .36000000-002
FLASK PRESSURE IS,PSI, .95403728+003      TUBE PRESSURE IS .95709239+003
X IS .35136959+000      XDOT IS  .32590026+002      VELDOT IS  .10044488+005UNITS OF FT,SEC
FORCE =  .15597030+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    37      TIME  .37000000-002
FLASK PRESSURE IS,PSI, .95403728+003      TUBE PRESSURE IS .94631671+003
X IS .35462899+000      XDOT IS  .33594476+002      VELDOT IS  .99146867+004UNITS OF FT,SEC
FORCE =  .15395179+006   POUNDSFORCE
PIECE HAS THE VALUE -.11908979+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    38      TIME  .38000000-002
FLASK PRESSURE IS,PSI, .95294148+003      TUBE PRESSURE IS .95631004+003
X IS .35798813+000      XDOT IS  .34585945+002      VELDOT IS  .10029989+005UNITS OF FT,SEC
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FORCE =  .15574517+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    39      TIME  .39000000-002
FLASK PRESSURE IS,PSI, .95294148+003      TUBE PRESSURE IS .94344601+003
X IS .3[illegible]4673+000      XDOT IS  .35588943+002      VELDOT IS  .98950684+004UNITS OF FT,SEC
FORCE =  .15365013+006   POUNDSFORCE
PIECE HAS THE VALUE -.96316357+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    40      TIME  .40000000-002
FLASK PRESSURE IS,PSI, .95179939+003      TUBE PRESSURE IS .95450311+003
X IS .3650052+000      XDOT IS  .36578450+002      VELDOT IS  .10011038+005UNITS OF FT,SEC
FORCE =  .15545089+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    41      TIME  .41000000-002
FLASK PRESSURE IS,PSI, .95179939+003      TUBE PRESSURE IS .94119270+003
X IS .3689631[illegible]+000      XDOT IS  .37579554+002      VELDOT IS  .98714352+004UNITS OF FT,SEC
FORCE =  .15328316+006   POUNDSFORCE
PIECE HAS THE VALUE -.73613183+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    42      TIME  .42000000-002
FLASK PRESSURE IS,PSI, .95059402+003      TUBE PRESSURE IS .95265808+003
X IS .3704214[illegible]+000      XDOT IS  .38566697+002      VELDOT IS  .99916866+004UNITS OF FT,SEC
FORCE =  .15315041+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    43      TIME  .43000000-002
FLASK PRESSURE IS,PSI, .95059402+003      TUBE PRESSURE IS .93693743+003
X IS .3762780[illegible]+000      XDOT IS  .39565866+002      VELDOT IS  .98477814+004UNITS OF FT,SEC
FORCE =  .15201[illegible].+006   POUNDSFORCE
PIECE HAS THE VALUE -.47061092+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    44      TIME  .44000000-002
FLASK PRESSURE IS,PSI, .94933219+003      TUBE PRESSURE IS .95065015+003
X IS .3802340[illegible]7+000      XDOT IS  .40550643+002      VELDOT IS  .99706271+004UNITS OF FT,SEC
FORCE =  .15462340+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    45      TIME  .45000000-002
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FLASK PRESSURE IS,PSI, .94933219+003      TUBE PRESSURE IS .93655695+003
X IS .38428973+000      XDOT IS  .41547706+002      VELDOT IS  .98228143+004UNITS OF FT,SEC
FORCE =  .15252817+006   POUNDSFORCE
PIECE HAS THE VALUE -.17978391+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    46      TIME  .46000000-002
FLASK PRESSURE IS,PSI, .94801318+003      TUBE PRESSURE IS .94851600+003
X IS .38844450+000      XDOT IS  .42529987+002      VELDOT IS  .99482435+004UNITS OF FT,SEC
FORCE =  .15147582+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    47      TIME  .47000000-002
FLASK PRESSURE IS,PSI, .94801318+003      TUBE PRESSURE IS .93408633+003
X IS .39289750+000      XDOT IS  .43524811+002      VELDOT IS  .97969020+004UNITS OF FT,SEC
FORCE =  .15212581+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    48      TIME  .48000000-002
FLASK PRESSURE IS,PSI, .94863817+003      TUBE PRESSURE IS .94625274+003
X IS .39704916+000      XDOT IS  .44504501+002      VELDOT IS  .99245060+004UNITS OF FT,SEC
FORCE =  .15410724+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    49      TIME  .49000000-002
FLASK PRESSURE IS,PSI, .94640789+003      TUBE PRESSURE IS .93591843+003
X IS .40150043+000      XDOT IS  .45496952+002      VELDOT IS  .98161174+004UNITS OF FT,SEC
FORCE =  .15242418+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    50      TIME  .50000000-002
FLASK PRESSURE IS,PSI, .94521354+003      TUBE PRESSURE IS .91374026+003
X IS .40605012+000      XDOT IS  .46478563+002      VELDOT IS  .98981545+004UNITS OF FT,SEC
FORCE =  .15309805+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    51      TIME  .51000000-002
FLASK PRESSURE IS,PSI, .94476401+003      TUBE PRESSURE IS .93713311+003
X IS .41069797+000      XDOT IS  .47468379+002      VELDOT IS  .98268573+004UNITS OF FT,SEC
FORCE =  .15262201+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    52      TIME  .52000000-002
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FLASK PRESSURE IS,PSI, .94374481+003     TUBE PRESSURE IS .940904C0+003
X IS .41544431+000     XDOT IS  .48451264+002     VELDOT IS  .98684136+004UNITS OF FT,SEC
FORCE =  .15323624+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    53     TIME  .53000000-002
FLASK PRESSURE IS,PSI, .94312177+003     TUBE PRESSURE IS .93703914+003
X IS .42028993+000     XDOT IS  .49438105+002     VELDOT IS  .98278717+004UNITS OF FT,SEC
FORCE =  .15260671+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    54     TIME  .54000000-002
FLASK PRESSURE IS,PSI, .94221206+003     TUBE PRESSURE IS .93814403+003
X IS .42523374+000     XDOT IS  .50420892+002     VELDOT IS  .98394600+004UNITS OF FT,SEC
FORCE =  .15278665+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    55     TIME  .55000000-002
FLASK PRESSURE IS,PSI, .94146771+003     TUBE PRESSURE IS .93597169+003
X IS .43027503+000     XDOT IS  .51404838+002     VELDOT IS  .98166761+004UNITS OF FT,SEC
FORCE =  .15243284+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    56     TIME  .56000000-002
FLASK PRESSURE IS,PSI, .94060368+003     TUBE PRESSURE IS .93567179+003
X IS .43541631+000     XDOT IS  .52386506+002     VELDOT IS  .98135306+004UNITS OF FT,SEC
FORCE =  .15238402+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    57     TIME  .57000000-002
FLASK PRESSURE IS,PSI, .93978540+003     TUBE PRESSURE IS .93429248+003
X IS .44068496+000     XDOT IS  .53367858+002     VELDOT IS  .97990641+004UNITS OF FT,SEC
FORCE =  .15215029+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    58     TIME  .58000000-002
FLASK PRESSURE IS,PSI, .93892261+003     TUBE PRESSURE IS .93342989+003
X IS .44589175+000     XDOT IS  .54347764+002     VELDOT IS  .97900171+004UNITS OF FT,SEC
FORCE =  .15201890+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    59     TIME  .59000000-002
FLASK PRESSURE IS,PSI, .93806034+003     TUBE PRESSURE IS .93229823+003
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X IS .45142652+000      XDOT IS  .55326766+002      VELDOT IS  .9776(1584+004UNITS OF FT,SEC
FORCE =  .15183475+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    60      TIME  .60000000-002
FLASK PRESSURE IS,PSI, .93717792+003     TUBE PRESSURE IS .93125963+003
X IS .45695920+000      XDOT IS  .56304582+002      VELDOT IS  .97672571+004UNITS OF FT,SEC
FORCE =  .15166548+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    61      TIME  .61000000-002
FLASK PRESSURE IS,PSI, .93628418+003     TUBE PRESSURE IS .93018232+003
X IS .46258965+000      XDOT IS  .57281307+002      VELDOT IS  .97557461+004UNITS OF FT,SEC
FORCE =  .15142674+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    62      TIME  .62000000-002
FLASK PRESSURE IS,PSI, .93537585+003     TUBE PRESSURE IS .92906429+003
X IS .46831778+000      XDOT IS  .58256882+002      VELDOT IS  .97442297+004UNITS OF FT,SEC
FORCE =  .15130792+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    63      TIME  .63000000-002
FLASK PRESSURE IS,PSI, .93445423+003     TUBE PRESSURE IS .92794543+003
X IS .47414347+000      XDOT IS  .59231305+002      VELDOT IS  .97324949+004UNITS OF FT,SEC
FORCE =  .15112570+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    64      TIME  .64000000-002
FLASK PRESSURE IS,PSI, .93351904+003     TUBE PRESSURE IS .92681265+003
X IS .47996634+000      XDOT IS  .60204554+002      VELDOT IS  .97206162+004UNITS OF FT,SEC
FORCE =  .15094125+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    65      TIME  .65000000-002
FLASK PRESSURE IS,PSI, .93257049+003     TUBE PRESSURE IS .92566433+003
X IS .48608705+000      XDOT IS  .61176615+002      VELDOT IS  .97085703+004UNITS OF FT,SEC
FORCE =  .15075420+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    66      TIME  .66000000-002
FLASK PRESSURE IS,PSI, .93160864+003     TUBE PRESSURE IS .92450117+003
X IS .49220471+000      XDOT IS  .62147472+002      VELDOT IS  .96963708+004UNITS OF FT,SEC
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FORCE =  .15056477+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    67      TIME  .67000000-002
FLASK PRESSURE IS,PSI, .93063365+003      TUBE PRESSURE IS .92332243+003
X IS .49841946+000      XDOT IS  .63117109+002      VELDOT IS  .96840078+004UNITS OF FT,SEC
FORCE =  .15037279+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    68      TIME  .68000000-002
FLASK PRESSURE IS,PSI, .92964557+003      TUBE PRESSURE IS .92212950+003
X IS .50473116+000      XDOT IS  .64085509+002      VELDOT IS  .96714961+004UNITS OF FT,SEC
FORCE =  .15017851+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    69      TIME  .69000000-002
FLASK PRESSURE IS,PSI, .92864455+003      TUBE PRESSURE IS .92092159+003
X IS .51113971+000      XDOT IS  .65052658+002      VELDOT IS  .96588273+004UNITS OF FT,SEC
FORCE =  .14998179+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    70      TIME  .70000000-002
FLASK PRESSURE IS,PSI, .92763068+003      TUBE PRESSURE IS .91969928+003
X IS .51761497+000      XDOT IS  .66018540+002      VELDOT IS  .96460076+004UNITS OF FT,SEC
FORCE =  .14978273+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    71      TIME  .71000000-002
FLASK PRESSURE IS,PSI, .92660406+003      TUBE PRESSURE IS .91846282+003
X IS .52424692+000      XDOT IS  .66983141+002      VELDOT IS  .96330393+004UNITS OF FT,SEC
FORCE =  .14958136+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    72      TIME  .72000000-002
FLASK PRESSURE IS,PSI, .92556484+003      TUBE PRESSURE IS .91721204+003
X IS .53094513+000      XDOT IS  .67946445+002      VELDOT IS  .96199208+004UNITS OF FT,SEC
FORCE =  .14937763+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    73      TIME  .73000000-002
FLASK PRESSURE IS,PSI, .92451310+003      TUBE PRESSURE IS .91594767+003
X IS .53773977+000      XDOT IS  .68908436+002      VELDOT IS  .96066598+004UNITS OF FT,SEC
FORCE =  .14917174+006   POUNDSFORCE
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THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     74      TIME  .74000000-002
FLASK PRESSURE IS,PSI, .92344897+003      TUBE PRESSURE IS .91466897+003
X IS .54463061+000      XDOT IS  .69869102+002      VELDOT IS  .95932484+004UNITS OF FT,SEC
FORCE =  .14096349+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     75      TIME  .75000000-002
FLASK PRESSURE IS,PSI, .92237253+003      TUBE PRESSURE IS .91337725+003
X IS .55161752+000      XDOT IS  .70828426+002      VELDOT IS  .95797006+004UNITS OF FT,SEC
FORCE =  .14875312+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     76      TIME  .76000000-002
FLASK PRESSURE IS,PSI, .92128394+003      TUBE PRESSURE IS .91207166+003
X IS .55070036+000      XDOT IS  .71786396+002      VELDOT IS  .95660074+004UNITS OF FT,SEC
FORCE =  .14854043+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .76499999+002
THIS IS THE CALC FOR POSITION     77      TIME  .77000000-002
FLASK PRESSURE IS,PSI, .92018328+003      TUBE PRESSURE IS .91075269+003
X IS .54987899+000      XDOT IS  .72742996+002      VELDOT IS  .95521737+004UNITS OF FT,SEC
FORCE =  .14832569+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     78      TIME  .78000000-002
FLASK PRESSURE IS,PSI, .91907066+003      TUBE PRESSURE IS .90942118+003
X IS .54915329+000      XDOT IS  .73698214+002      VELDOT IS  .95362085+004UNITS OF FT,SEC
FORCE =  .14810383+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     79      TIME  .79000000-002
FLASK PRESSURE IS,PSI, .91794623+003      TUBE PRESSURE IS .90807634+003
X IS .54842310+000      XDOT IS  .74652034+002      VELDOT IS  .95241035+004UNITS OF FT,SEC
FORCE =  .14788981+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     80      TIME  .79999999-002
FLASK PRESSURE IS,PSI, .91681008+003      TUBE PRESSURE IS .90671877+003
X IS .54798830+000      XDOT IS  .75604444+002      VELDOT IS  .95098651+004UNITS OF FT,SEC
FORCE =  .14766871+006   POUNDSFORCE

THE VALVE IS UNCHOKED
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THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     81      TIME  .81000000-002
FLASK PRESSURE IS,PSI, .91566234+003      TUBE PRESSURE IS .90534877+003
X IS .5955487+000      XDOT IS  .76555429+002      VELDOT IS  .94954962+004UNITS OF FT,SEC
FORCE =  .14744559+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     82      TIME  .81999999-002
FLASK PRESSURE IS,PSI, .91450311+003      TUBE PRESSURE IS .90396615+003
X IS .6032042E+000      XDOT IS  .77504978+002      VELDOT IS  .94809950+004UNITS OF FT,SEC
FORCE =  .14722042+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     83      TIME  .83000000-002
FLASK PRESSURE IS,PSI, .91333253+003      TUBE PRESSURE IS .90257124+003
X IS .6109547E+000      XDOT IS  .78453077+002      VELDOT IS  .94663649+004UNITS OF FT,SEC
FORCE =  .14699324+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     84      TIME  .83999999-002
FLASK PRESSURE IS,PSI, .91215070+003      TUBE PRESSURE IS .90116450+003
X IS .6188000E+000      XDOT IS  .79399714+002      VELDOT IS  .94516106+004UNITS OF FT,SEC
FORCE =  .14676414+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     85      TIME  .85000000-002
FLASK PRESSURE IS,PSI, .91095775+003      TUBE PRESSURE IS .89974574+003
X IS .6267400E+000      XDOT IS  .80344874+002      VELDOT IS  .94367303+004UNITS OF FT,SEC
FORCE =  .14653308+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     86      TIME  .85999999-002
FLASK PRESSURE IS,PSI, .90975378+003      TUBE PRESSURE IS .89831516+003
X IS .6347745E+000      XDOT IS  .81288547+002      VELDOT IS  .94217261+004UNITS OF FT,SEC
FORCE =  .14630019+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION     87      TIME  .87000000-002
FLASK PRESSURE IS,PSI, .90853892+003      TUBE PRESSURE IS .89687324+003
X IS .6429033E+000      XDOT IS  .82230719+002      VELDOT IS  .94066041+004UNITS OF FT,SEC
FORCE =  .14606529+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
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THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    88      TIME  .88000000-002
FLASK PRESSURE IS,PSI, .90731329+003      TUBE PRESSURE IS .89541975+003
X IS .65112645+000      XDOT IS  .83171378+002      VELDOT IS  .93913584+004UNITS OF FT,SEC
FORCE =  .14582855+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    89      TIME  .89000000-002
FLASK PRESSURE IS,PSI, .90607700+003      TUBE PRESSURE IS .89395531+003
X IS .65944359+000      XDOT IS  .84110514+002      VELDOT IS  .93759991+004UNITS OF FT,SEC
FORCE =  .14559005+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    90      TIME  .90000000-002
FLASK PRESSURE IS,PSI, .90483020+003      TUBE PRESSURE IS .89247967+003
X IS .66785464+000      XDOT IS  .85048113+002      VELDOT IS  .93605222+004UNITS OF FT,SEC
FORCE =  .14534972+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    91      TIME  .90999999-002
FLASK PRESSURE IS,PSI, .90357298+003      TUBE PRESSURE IS .89099311+003
X IS .67635944+000      XDOT IS  .85984164+002      VELDOT IS  .93449309+004UNITS OF FT,SEC
FORCE =  .14510762+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    92      TIME  .92000000-002
FLASK PRESSURE IS,PSI, .90230546+003      TUBE PRESSURE IS .88949578+003
X IS .68495795+000      XDOT IS  .86918657+002      VELDOT IS  .93292266+004UNITS OF FT,SEC
FORCE =  .14486377+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    93      TIME  .92999999-002
FLASK PRESSURE IS,PSI, .90102776+003      TUBE PRESSURE IS .88798828+003
X IS .69364972+000      XDOT IS  .87851580+002      VELDOT IS  .93134156+004UNITS OF FT,SEC
FORCE =  .14461826+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    94      TIME  .94000000-002
FLASK PRESSURE IS,PSI, .89974003+003      TUBE PRESSURE IS .88647019+003
X IS .70243487+000      XDOT IS  .88782921+002      VELDOT IS  .92974935+004UNITS OF FT,SEC
FORCE =  .14437102+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
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THIS IS THE CALC FOR POSITION    95      TIME  .94999999-002
FLASK PRESSURE IS,PSI, .89844236+003      TUBE PRESSURE IS .85494170+003
X IS .71131316+000      XDOT IS  .89712669+002      VELDOT IS  .92814624+004UNITS OF FT,SEC
FORCE =  .14412209+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    96      TIME  .96000000-002
FLASK PRESSURE IS,PSI, .89713487+003      TUBE PRESSURE IS .88540356+003
X IS .72028412+000      XDOT IS  .90640815+002      VELDOT IS  .92653301+004UNITS OF FT,SEC
FORCE =  .14387159+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    97      TIME  .96999999-002
FLASK PRESSURE IS,PSI, .89581770+003      TUBE PRESSURE IS .88185546+003
X IS .72934850+000      XDOT IS  .91567348+002      VELDOT IS  .92490933+004UNITS OF FT,SEC
FORCE =  .14361946+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    98      TIME  .98000000-002
FLASK PRESSURE IS,PSI, .89449096+003      TUBE PRESSURE IS .88029767+003
X IS .73650524+000      XDOT IS  .92492256+002      VELDOT IS  .92327548+004UNITS OF FT,SEC
FORCE =  .14336576+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION    99      TIME  .98999999-002
FLASK PRESSURE IS,PSI, .89315476+003      TUBE PRESSURE IS .87873031+003
X IS .74775446+000      XDOT IS  .93415531+002      VELDOT IS  .92163159+004UNITS OF FT,SEC
FORCE =  .14311650+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION   100      TIME  .10000000-001
FLASK PRESSURE IS,PSI, .89180923+003      TUBE PRESSURE IS .87715379+003
X IS .75709601+000      XDOT IS  .94337162+002      VELDOT IS  .91997811+004UNITS OF FT,SEC
FORCE =  .14286374+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION   200      TIME  .20000000-001
FLASK PRESSURE IS,PSI, .72920174+003      TUBE PRESSURE IS .69080135+003
X IS .21204487+001      XDOT IS  .17717900+003      VELDOT IS  .73082052+004UNITS OF FT,SEC
FORCE =  .11246135+006   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION   300      TIME  .30000000-001
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FLASK PRESSURE IS,PSI, .56383281+003      TUBE PRESSURE IS .52915401+003
X IS .42300144+001      XDOT IS  .24123565+003      VELDOT IS  .55498832+004UNITS OF FT,SEC
FORCE =  .86178312+005   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION   400      TIME  .40000000-001
FLASK PRESSURE IS,PSI, .43043994+003      TUBE PRESSURE IS .40173729+003
X IS .68837501+001      XDOT IS  .28976893+003      VELDOT IS  .42165087+004UNITS OF FT,SEC
FORCE =  .65427154+005   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION   500      TIME  .50000000-001
FLASK PRESSURE IS,PSI, .33126063+003      TUBE PRESSURE IS .30987960+003
X IS .99830960+001      XDOT IS  .32686692+003      VELDOT IS  .32500851+004UNITS OF FT,SEC
FORCE =  .50467160+005   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION   600      TIME  .60000000-001
FLASK PRESSURE IS,PSI, .25926801+003      TUBE PRESSURE IS .24397366+003
X IS .13400526+002      XDOT IS  .35575774+003      VELDOT IS  .25588512+004UNITS OF FT,SEC
FORCE =  .39723715+005   POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN)  .78499999+002
THIS IS THE CALC FOR POSITION   700      TIME  .69999999-001
FLASK PRESSURE IS,PSI, .20694791+003      TUBE PRESSURE IS .19610556+003
X IS .17075995+002      XDOT IS  .37873104+003      VELDOT IS  .20567980+004UNITS OF FT,SEC
FORCE =  .31937858+005   POUNDSFORCE

*****FINAL VELOCITY IS  .39322717+003 FT/SEC
X=  .20010107+002     PTUBE=  .16828612+003     PFLASK=  .17666909+003 PSI
I IS  776     T IS  .77599999-001


                  PLOTTING COMMENCING
                  ...................

..... DISSPLA VERSION 9.0 .....
NO. OF FIRST PLOT  1



PLOT NO.   1 WITH THE TITLE
```

```
PRESSURE CHARACTERISTICS
HAS BEEN COMPLETED.

PLOT ID. READS
PLOT 1     10.01.04  MON  26 JUL, 1982
  JOB=LEARN                    DISSPLA 9.0

DATA FOR PLOT

NO. OF CURVES DRAWN  2
------------------------------
HORIZ. AXIS LENGTH    6.0 INS.
VERT. AXIS LENGTH     8.0 INS.
------------------------------
HORIZ. ORIGIN  .0000
VERT.  ORIGIN  .0000
------------------------------
HORIZ. AXIS LINEAR
STEP SIZE  .0667-001 UNITS/INCH
------------------------------
VERT.  AXIS LINEAR
STEP SIZE  .2000+003 UNITS/INCH
------------------------------

    .....................................
    . LOCATION OF CURRENT PHYSICAL ORIGIN .
    . X=   1.50      Y=   1.12     INCHES .
    .    FROM LOWER LEFT CORNER OF PAGE   .
    .....................................

                PLOTTING COMMENCING
                ...................

..... DISSPLA VERSION 9.0 .....
NO. OF FIRST PLOT  2

PLOT NO.   2 WITH THE TITLE
MISSILE VELOCITY
HAS BEEN COMPLETED.

PLOT ID. READS
```

```
PLOT 2     10.01.06  MON  26 JUL, 1982
  JOB=LEARN                    DISSPLA 9.0

DATA FOR PLOT

NO. OF CURVES DRAWN  1
-----------------------------
HORIZ. AXIS LENGTH    6.0 INS.
VERT. AXIS LENGTH     8.0 INS.
-----------------------------
HORIZ. ORIGIN  .0000
VERT.  ORIGIN  .0000
-----------------------------
HORIZ. AXIS LINEAR
STEP SIZE  .5833+001 UNITS/INCH
-----------------------------
VERT.  AXIS LINEAR
STEP SIZE  .8750+002 UNITS/INCH
-----------------------------

    ........................................
    . LOCATION OF CURRENT PHYSICAL ORIGIN .
    . X=   1.50      Y=   1.12      INCHES .
    .   FROM LOWER LEFT CORNER OF PAGE     .
    ........................................


                  PLOTTING COMMENCING
                  ...................

..... DISSPLA VERSION 9.0 .....
NO. OF FIRST PLOT  3



PLOT NO.   3 WITH THE TITLE
MISSILE ACCELERATION
HAS BEEN COMPLETED.

PLOT ID. READS
PLOT 3     10.01.08  MON  26 JUL, 1982
  JOB=LEARN                    DISSPLA 9.0
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```
DATA FOR PLOT

NO. OF CURVES DRAWN  1
-----------------------------
HORIZ. AXIS LENGTH    6.0 INS.
VERT. AXIS LENGTH     8.0 INS.
-----------------------------
HORIZ. ORIGIN  .0000
VERT.  ORIGIN  .0000
-----------------------------
HORIZ. AXIS LINEAR
STEP SIZE  .6667-001 UNITS/INCH
-----------------------------
VERT.  AXIS LINEAR
STEP SIZE  .5000+002 UNITS/INCH
-----------------------------

    ........................................
    . LOCATION OF CURRENT PHYSICAL ORIGIN .
    . X=   1.50      Y=   1.12     INCHES .
    .    FROM LOWER LEFT CORNER OF PAGE    .
    ........................................

            6 FRAMES     23085 PLOTWORDS        7 MINUTES

END OF DISSPLA 8.2 --     8843 VECTORS GENERATED IN     3 PLOT FRAMES.
-ISSCO-  4186 SORRENTO VALLEY BLVD.,SAN DIEGO CALIF. 92121

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   IS SUBJECT TO A NONDISSEMINATION AND NONDISCLOSURE AGREEMENT.

2349 VIRTUAL STORAGE REFERENCES: 4 READS; 0 WRITES.

STOP    REACHED END OF PROGRAM
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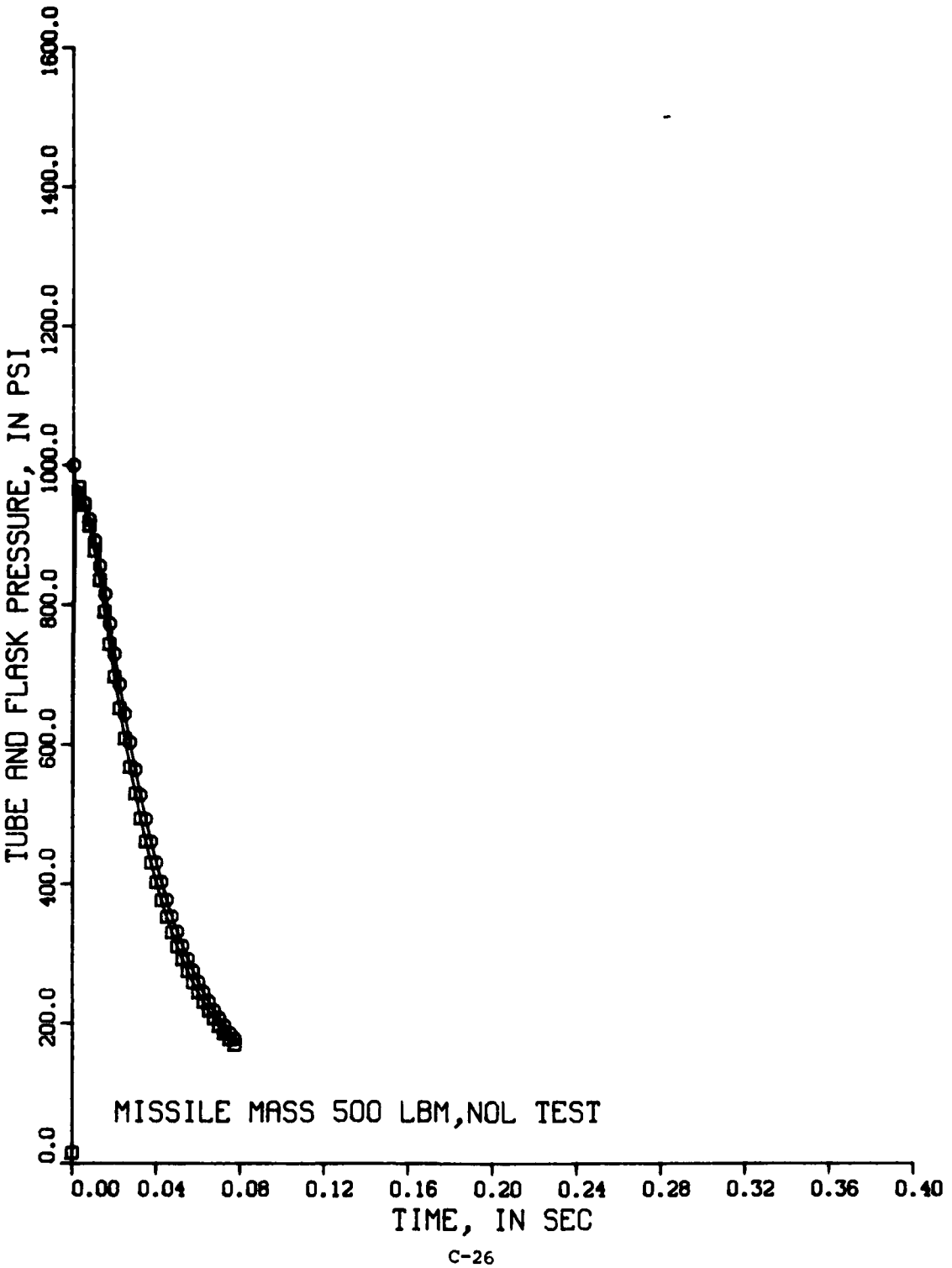
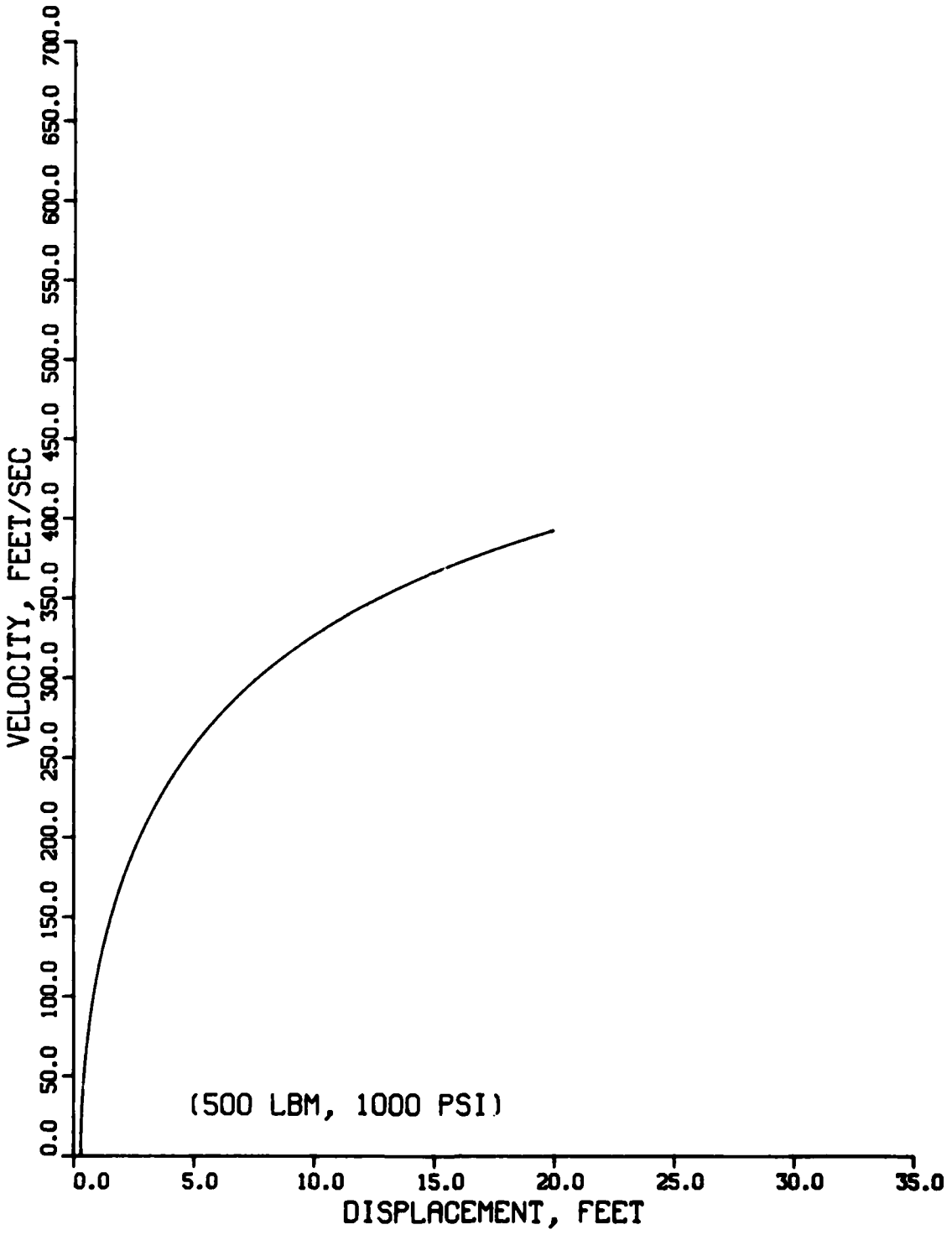
PRESSURE CHARACTERISTICS



C-26

MISSILE VELOCITY



MISSILE ACCELERATION